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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over 700 men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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ALFRED E. MARTIN.

President New England Water Works Association.

1908.

NEW ENGLAND WATER WORKS ASSOCIATION.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

EXPERIENCE WITH A PRODUCER GAS PLANT.

BY HARRY L. THOMAS, ASSISTANT SUPERINTENDENT, HINGHAM WATER COMPANY, HINGHAM, MASS.

[*Read January 8, 1908.*]

In presenting this paper I do so with a considerable degree of timidity when I realize that the duty falls upon me to introduce to this Association the application of producer gas to the needs of our business as water-works superintendents and officials, and it would undoubtedly have been wiser had a more general treatise been first presented by an eminent authority, to be followed by the experience papers of us "small fry." But I wish in no way to question the wisdom or judgment of our worthy secretary, by whose urgent request this matter is presented, and the announcement borne upon the notice for this meeting, "Experience with a Producer Gas Plant," will surely lead you gentlemen to anticipate nothing but an account of the most ordinary everyday experiences which have come to us in the management of our new station and its equipment. Whatever is here presented is but a meager part of our experience. There is much that can better be told to an attentive ear than recorded in this paper; therefore should I fail to make clear the descriptions, and this treatise fall short of your expectations, rest assured that at any time you feel inclined to pay us a visit, by dropping us a line at the office in advance, my time and an automobile will very gladly be placed at the disposal of any of you gentlemen.

Our plant was installed in the spring of 1906, the test being made in May of that year. It is located at Fulling Mill Pond, one of our

sources of supply, and during the summer season, when the greatest demand is made on the system, is used to pump water to the receiving basin at the Weir River Station through 20 000 feet of 14-, 12-, and 10-inch pipe. From there the water is again pumped into the distributing system by a Deane steam pump. Lest surprise be felt at the handling of the water twice over, let me explain that it is contemplated to, in the near future, dispense with our steam plant, and by increasing the number of units of the producer plant, and providing suitable mains, do all our pumping at Fulling Mill Pond.

The entire equipment, producer, engine, and pump, was furnished and installed under contract by the Olds Gas Power Company, of Lansing, Mich., and consists of a Pintsch system suction gas producer of size to furnish sufficient gas to generate 70 horsepower; a 65 horse-power, single cylinder, Olds heavy duty, type K gas engine; a 13 × 12 Smith-Vaile single-acting, outside packed plunger, triplex pump; and a compressed air starting outfit. The foundations, furnished by the water company, are of concrete, and the whole is housed in a wooden frame building 30 × 36 feet, situated 50 feet from a collecting well 40 feet in diameter and 20 feet deep, from which the water is pumped, and so placed that the center line of the pump is parallel to, and 15 feet from, the 14-inch pipe leading from the well. The building, which is temporary, built to accommodate the present unit until such time as others are added, is very plain, as the photograph will show, and is divided into two rooms by a tight partition running from floor to roof, separating the engine and pump from the producer, made necessary by the unavoidable dust and ashes consequent upon cleaning the fire in the generator.

The photographs which are reproduced in Plates I and II show what the machines look like, but can hardly give a definite idea of their relative arrangement, and in order to make this clear we will consider it for a moment by beginning in the producer room. This is 30 × 13 feet, the floor being for the most part of brick, as in cleaning the fire some live coals are very apt to roll out. First stands the generator in which the gas is made. It is cylindrical in form, 3 feet 6 inches diameter by 7 feet 6 inches high, inside measures, and is supported by three iron legs which raise

FIG. 1. FULLING MILL POND PUMPING STATION, HINGHAM WATER CO.

FIG. 2. CHARGING FLOOR, SHOWING CHARGING HOPPER OF GENERATOR.

it 2 feet from the floor. It is lined with courses of properly molded fire brick 8 inches in thickness, the joints being made up with fire clay. Between the shell and this lining is a space of 1 inch, and after each course of brick was laid this space was very carefully filled with mineral wool to avoid the possibility of any air working in and either affecting the composition of the gas or creating an air pocket to retard the flow of the same. The bottom course of brick rests upon the frame supporting the shaking grate, which is funnel-shaped, provided with a draw center. On either side of the generator are two doors, one above the other, the upper one opening at the top of the grate, allowing space for cleaning and poking the fire, the lower one giving opportunity for shaking and drawing the grate when necessary to work out an accumulation of clinker. From the bottom of the generator a tube 10 inches in diameter leads down to a water-sealed ash pit, thus enabling the removal of ashes without admitting an undue amount of air into the fire. Such is the nature of producer gas that the proper amount of air admitted to the fire is of vital importance, and unless great care is exercised, perplexing results are inevitable. In operation we have sometimes found that under certain conditions of fire and fuel the opening of the fire or grate doors for more than half a minute at a time was impossible without producing trouble.

The generator is filled and fed from the top, for this purpose a cast-iron charging hopper being provided which will hold 85 pounds of coal. When charging becomes necessary the hopper is filled, its cover closed and fastened, and it is then swung around until it comes over a hole in the center of the top, when the coal simply runs down into the fire; the hopper is then swung back ready to receive another charge. By means of a ground joint this hopper is self-sealed, again guarding against improper admission of air.

At one side of the generator is situated an apparatus for injecting steam and air into the fire. These are both admitted through the same pipe into the ash tube previously referred to, and the present apparatus, which has replaced that originally attached, is most satisfactory in its working. It is provided with proper valves to regulate both air and steam.

Standing beside the generator is the vaporizer, cast iron, of the independent type, having a water-sealed cleaning pot and a relief chimney to the atmosphere. In this is generated the steam for use in the fire. It is cylindrical in form and built in three sections bolted together, the bottom part providing the seal for the generator as well as a cleaning pot for the vaporizer itself. The middle section contains a number of 1-inch tubes surrounded by water, and during operation the hot gas passing down through these tubes generates the steam, which passes to the injector before alluded to through a 1½-inch pipe leading out from the upper section, which is provided with a water jacket to which is attached a gage glass and overflow pipe. The gas port from the generator comes into this upper section, and is reached for cleaning by removing the flat top of the vaporizer, which also gives access to the tubes when it becomes necessary to brush them. Connected with the bottom section is the relief or chimney pipe.

Next stands the scrubber, provided with a grate placed about 18 inches from the bottom, and from this to the filling door near the top this is filled with clean egg size coke. Through its top projects a 1¼-inch pipe, having on its end a perforated ball from which, during operation, a spray of water is constantly pouring. In this machine the gas gets its principal cleaning and is cooled by the water spray, more or less water being used as the temperature of the gas requires.

The next and last machine through which the gas passes is the cleaner or dry scrubber, which is fitted with two grates, one above the other, 8 inches apart, upon which are evenly distributed clean mill shavings to the depth of 3 inches, and to prevent these dropping through the grates, coarse mesh burlap is laid on. It is 4 feet 8 inches in diameter, so made that the whole top may be lifted to provide easy access for cleaning. In our plant we consider this machine plays a most important part in preparing the gas for the engine by removing any tar, carbon, or dirt which may pass along with the gas, thereby assuring cleaner valves, gas ports, and combustion chamber than could reasonably be expected without this cleaning; and great pains are taken that the filling of shavings shall at all times be evenly distributed and the layers of proper thickness. When at any time evidence of dirty gas is found, our first care is given to this machine.

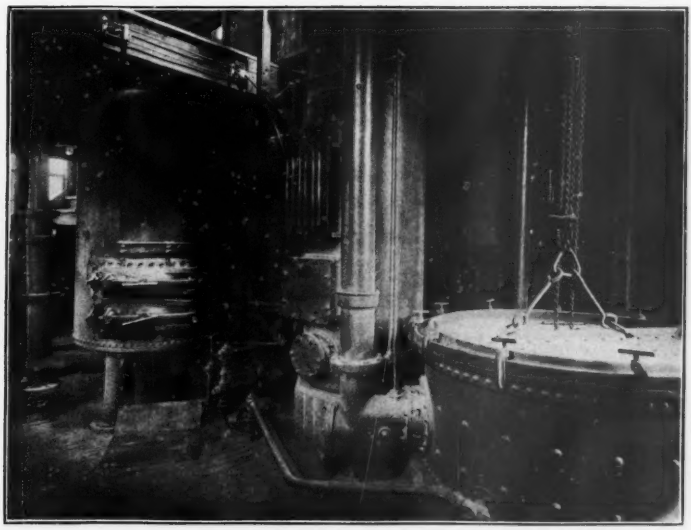


FIG. 1. PRODUCER ROOM, SHOWING GENERATOR, VAPORIZER, SCRUBBER, AND CLEANER.

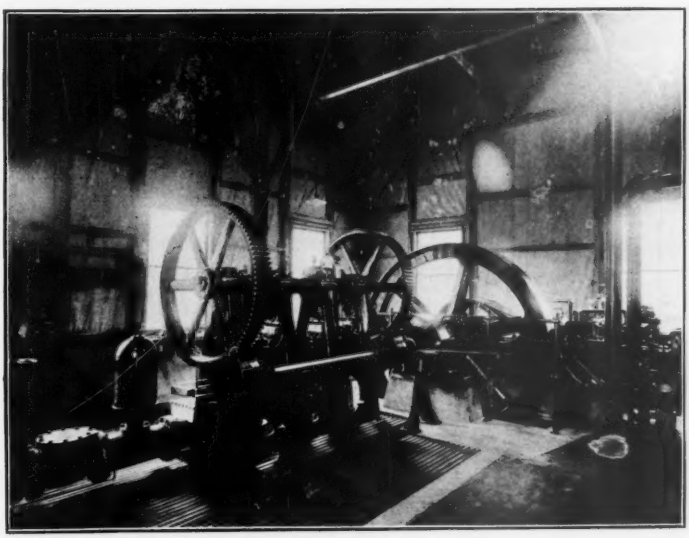


FIG. 2. ENGINE AND PUMP ROOM.

The four machines just described constitute what is termed the producer, from the fact that they all figure in the preparation of the gas. In the same room with these is the compressed air starting outfit, comprising a small compressor driven by a belt from a gasoline engine with the necessary storage tank. Belted to this same engine is the blower used when starting the fire in the generator.

The engine, four cycle, single cylinder, is very compactly built, measuring approximately 11 feet × 4 feet 3 inches; the top of the governor, which is the highest point, being 5 feet from the floor, and the fly wheel, 9 feet in diameter with a 12-inch face, weighing 8 000 pounds. The crank shaft is 6 inches in diameter in bearings, the main and outboard bearings being of the ring oiler type with babbitt-lined boxes. The connecting rod is a solid steel forging, fitted at the crank end with a babbitted box and at the wrist pin end with a phosphor bronze box. When originally installed, the crank pin was oiled by a centrifugal oil ring fastened to the crank cheek and fed from a sight feed oiler, but after numerous experiences with a hot crank pin, melted box linings, etc., this was replaced by a wiper, and a great source of trouble and worry removed. For lubricating the wrist pin, piston, and exhaust valve stem, a sight feed pressure pump attached to the engine bed and operated by the side shaft is used. The speed is regulated by a Jahn's governor working on the common air and gas valve, and ignition is furnished by a Bosch magneto.

The pump, which is of the triplex geared type, is connected with the engine by a friction clutch and, when running at rated speed of forty-two revolutions per minute, will deliver one and one quarter million gallons in twenty-four hours, this being the duty which will be required of this unit when the contemplated plant is complete.

I shall assume that for the purposes of this paper the foregoing descriptions are sufficient, but if they prove not to be, perhaps more can be brought out in any discussion which may follow, and it may be well to now consider briefly the matter of generating the gas and its progress to the engine.

A wood fire is first built, and when this is well going, anthracite pea coal is put in until the generator is filled to its full capacity, 1 260 pounds. As soon as practicable the blower is applied, but

we are always careful not to blow too hard with a fresh fire, as it is an easy matter to overheat the grate, particularly if coke is used for a foundation. In our practice we never start the plant with an absolutely fresh fire, — not that it cannot be done if necessary, but we prefer to have a cooler fire to work with, which we get by building it up slowly until in proper condition and then allowing it to stand over night. During the building up of the fire, and until the proper quality of gas is obtained, the chimney pipe is kept wide open to provide draft and an outlet for waste gases, and under ordinary conditions an hour's blowing is necessary.

In order to test the gas a $\frac{3}{8}$-inch cock is tapped into the lower section of the vaporizer above the water seal, and when the gas from this will burn with a firm, full blue flame having a yellow tip, we consider we have it in sufficient quantity and proper quality to be blown over to the engine. If, however, when testing, we get an all-yellow flame, experience prompts us to let that gas go up chimney, as it is so hot that it cannot be properly cooled before reaching the engine; and should we start with it, preignition would inevitably result, attended by uncomfortable circumstances.

Having obtained a good test of gas at the generator, we are now ready to blow over. Tapped into the gas main near the engine is a $1\frac{1}{2}$-inch pipe which is fitted with a plug stop and running out to the atmosphere; and near this pipe is placed a second test cock. With the blower still running, this pipe is opened, the water seal emptied, and the chimney pipe closed. This allows all the gas to be carried through the various machines to the engine, with the relief at the engine instead of at the generator as before. When good gas comes from this cock the water seal at the generator is refilled, chimney pipe opened, and a few minutes more of blowing, to be sure that the generator is well filled and the fire hot, makes us ready to start.

Right here it may be of interest to follow the course of gas to the engine. It leaves the generator at the top, entering the vaporizer at its top and, passing down through the tubes, passes out at the bottom. As has already been said, in passing through the tubes it generates the steam, which under good conditions

takes about thirty minutes. Then entering the scrubber at the bottom, it is drawn up through the coke, where it is met by the spray of water before mentioned, and, passing out through the port at the top, is drawn through the gas main to the top of the cleaner. Here it passes through the shavings and escapes through the bottom to the engine. In its entire course it is drawn along by the suction of the engine piston, and it is, therefore, quite impossible that any gas can escape; and it also becomes imperative, for the same reason, that no leaky joint or fixture shall admit of any air being drawn in at other than legitimate places.

Having blown the generator hot, as we term it, with a view to starting, the water seal is again emptied, chimney pipe closed, one of the fire doors opened just a little to be sure that some vent for gas confined in the generator is provided, and the throttle valve in the gas main at the engine opened. The engine is then started by compressed air, and under favorable conditions, after three or four revolutions, we get explosions in the combustion chamber; the air is shut off, the lever which controls timing of ignition properly adjusted, and our engine is fairly under way. But alas! one very important detail has been omitted from the rather confusing sequence of maneuvers, and I ask you kindly to assume that the wire connecting magneto and igniter has been put in place, with the humble assurance that not only was it omitted from the proper place in this narrative but, to the inexpressible chagrin of all concerned, it has sometimes been omitted in actual practice. (This was in the early days.) The generator door is now tightly closed, the air feed pipe from atmosphere opened, blower pipe shut off, the clutch pulley thrown in, and the several oil and bearing cups adjusted for the day. After the engine has been fairly under way the water is turned on for the scrubber spray, the proper feeding of which is very essential.

As closely as I can transcribe them, these are the steps taken in starting up the engine and pump, and the next topic might naturally relate to our experiences, sublime, ridiculous, and exasperating, and which, in justice to the subject as announced, perhaps should have formed the sole and important body of this paper. I trust my descriptions have in no great degree been tiresome to you, for I felt that a certain amount were necessary that you might

better follow my thought; and that those unaccustomed to such installations could gain a faint idea of the make-up of this particular system of gas producer.

The proposal offered by the firm that installed our plant includes among others the following clause:

"We are to furnish a representative to operate the plant for thirty days after the installation, whose duty it will be to properly instruct such representatives as you may appoint in the duties involved in the successful operation of both producer and engine."

What would have happened had not such instruction been placed at our disposal can, I assure you, be better imagined than recorded, for, in spite of the persistent and patient efforts of the aforesaid representative of the party of the first part to imprint upon the memory wise and serious truths, after the expiration of the aforesaid thirty days the aforesaid representatives of the party of the second part were promptly and on divers occasions "stuck for fair." Whereupon aforesaid representatives of the party of the second part did loudly and wildly utter such strange and unseemly language as would be unbecoming in this transcript. I am not breaking confidences when I relate any of our experiences, and lest any of you may be apprehensive, let me say that we have, for our purpose, an excellent plant, doing good continuous service and, under the charge of two reliable engineers, keeping well up to the standard of economy and efficiency for which such claims were made.

A very early difficulty encountered was the proper handling of the fire, and many times, after looking everywhere else for the source of the trouble, we were brought face to face with poor conditions at the generator, with gas of insufficient quantity and inferior quality. The experience of both operators as steam engineers was of no material benefit, and frequently the stoking bar was hung up with a bang, accompanied by the remark, "I thought I knew how to run a fire, but, after all, I guess I don't." They did understand running a steam boiler, but this was an entirely new process of firing, to be mastered only by failures and hard knocks, and we pride ourselves that now we have, in great measure, conquered the difficulty, and while a change in the grade of coal may occasionally cause slight inconvenience, we are able to cope

with it in an understanding manner and without disastrous results.

Under favorable conditions of fuel, the body of incandescent coal is about 18 or 20 inches deep, and the gas, carbon monoxide, is generated by the proper combining of certain elements during the passage of air and steam through the fire. But the proper combining in the early days was an uncertain quantity, and the entry in the record book by our engineer, " Started engine 8 A.M., ran ten minutes, and then fainted," recalls vividly to my mind many a heart-rending scene which resembled the time when, in younger days, we got the swing well under way and then stood to " let the old cat die."

Now the conditions which led up to this entry were these: The fire had been blown as usual and gas of good quality had been tested at both cocks; but at the end of the ten minutes all the gas had been exhausted from the machines, and what was being generated was not sufficient to supply the wants of the engine. This lack of gas was due to the presence in the fire of a large amount of hard clinker, and the clinker had been caused by improper proportioning of steam and air under the grate. Had more steam been admitted, while possibly clinker might have been present, it would have been at least porous, and the choking of the flow of gas reduced.

Again, the air was furnishing the major quantity of oxygen consumed, and its other element, nitrogen, an inert gas, was present in sufficient volume to displace other gases necessary for combustion. The record states that several trials were made to start, with similar results, and further attempts were abandoned until the fire had been thoroughly overhauled, which was accomplished by slicing from the top through a poke hole provided for that purpose, and using great care that any clinker attached to the lining was broken off. Then from the fire doors, by the use of a hooked bar, these were withdrawn and the generator filled with fresh coal, after which the blower was applied and the usual course pursued. It may be best to say here that the clinker which did the mischief had been accumulating during the run on the previous day, thereby leaving us a dirty fire with which to start.

Equally perplexing results were experienced later in our oper-

ating, and I again refer to the engineer's record book and find there entered, " Fourth of July for five minutes; then ran nice for a few minutes. At 8.25 down and out." Gentlemen, the utter abandon which prompted this entry can only be appreciated by those who, while working in ignorance and struggling with inexperience, try to make themselves and others believe that at last they understand operating a producer gas plant, and the cause of this entry may naturally be spoken of now. Whereas in the previous case steam was lacking, the difficulty was now due to an over-abundance of it, together with a hot fire; and the highly explosive hydro-carbons, which were in excess, were taken over to the engine and very heavy explosions occurred, which could not only be heard, but plainly felt in the vibration of the combustion chamber end of the engine. At the particular time in question, pre-ignition also contributed to the general fuss, brought about by a dirty combustion chamber, and from the fact that the heavy charge was ignited in the chamber before the admission valve was wholly closed, the force of the explosion was felt way back to the cleaner, where the shavings were disturbed by the current passing in the opposite direction from that intended. The noise produced by these explosions was extremely loud, both in the gas main and exhaust pipe, and when it occurred, as it sometimes did, during a calm summer night, the neighbors a mile distant became alarmed lest our quiet old town had been attacked by a battery of twelve-pounders. The explosions would continue for three or four minutes in rapid succession, during which time we cudgeled our brains for a cause, and usually resulted, as recorded by the engineer, in stopping the engine.

By the aid of the representative of the party of the first part we soon came to understand that here again we must look to the generator for the seat of difficulty and cool the fire; at the same time reduce the steam. " But," we argued, " we were told that we must have steam to cool the fire, and in order to get that quickly for the purpose we must have a hot fire, and hot fire and steam give this result. What is to be done? " Well, the only thing that could be done just then was to cut off the steam and run chances that our fuel would not clinker badly until matters came to rights and we again had command of the situation. In

this case, also, ignorance allowed us to let the fire get beyond us and become so hot that steam in sufficient quantity to cool it did its own peculiar mischief. I am free to say that of all the " kinks " accompanying the plant, this one of proper firing is by far the most important, and one which no amount of instruction and reading, unless accompanied by experience, can make plain, very many details of fuel, fire, air, and steam under varying conditions having a direct bearing upon results.

To aid in selecting fuel, calorimeter tests were made, with the result that the sample first selected contained 13 150 British thermal units per pound of dry coal, and during the test of the plant and for some time after this gave good results. The second purchase was made after a sample was tested, showing 12 998 B. T. U. per pound of dry coal and 8.4 per cent. ash; but a radical change in the condition of the fire became apparent by its use, and despite our best efforts we could not keep it cool. Another new feature appeared in the shape of a very deep body of incandescent coal, and it seemed impossible to prevent the fire working up high in the generator. This was first noted when, after running the bar up into the fire, no fresh coal would follow down. The clinker removed was of an entirely different character; it came out in large patches like masses of soft rubber, finally accumulating, despite our efforts, in a solid mass at the top of the fire doors that would nearly support the entire body of fuel. Steam was being admitted, we knew, in maximum quantity for safety, and the engine, while it continued to run, was pulling for gas very hard. Against all reason and practice, in order to ease up this pull, the fire was poked from the top every half hour, and it was observed that the hole made by the poke bar remained open and that the blowing of excess steam from the safety valve also stopped. We were brought to conclude, therefore, that the fire was filled with this mass of peculiar soft clinker, and that when the bar was withdrawn chimneys of hot gas, which are most undesirable, were formed, and not only was the fire, by reason of the frequent pokings, burning high, but we were making hot gas and paving the way for more Fourth of July stunts, which soon spoke for themselves.

But luck comes to every one sometime, and while shut down for

an hour to clean valves and change igniters we noticed a heavy deposit resembling sulphur in appearance and odor, and the thought came to me that I had read that sulphur was a great enemy to a gas producer. Reference proved my memory correct, and here we had the explanation of our difficulty, for the sulphur, which usually occurs as iron sulphide, in melting had formed a base around which clinkers had formed in vast quantities, and any effort to prevent this would prove futile. The ultimate result was that the fire was drawn from the generator, and the coal for future running was purchased and still is purchased from a local dealer who furnishes us pea coal screened from the various bins on his wharf, which is proving excellent for our use. Coal with a high per cent. of ash can be used very nicely if the percentage of sulphur is low, but the foregoing experience easily proves what may happen if sulphur is present in excessive proportion.

Other experiences by which we have profited have come to us and are still coming: adjustments of admission and mixing valves; the best point for ignition under varying circumstances; proper amount of oil required to lubricate piston without overfeeding and consequent burning; regulation of water spray in scrubber; care of cleaner with a view to preventing any considerable amount of dirt or carbon being carried to the engine; methods by which "back fires" may be quickly and quietly stopped, if not prevented; and numerous others which it seems not necessary to detail, as they vary with us, as they would anywhere else with local conditions of plant and fuel. Those I have spoken of are, I am satisfied, very likely to fall to the lot of any one who, as we have, operates a producer gas plant without any previous experience, unless an abundance of good luck comes his way.

The results obtained from the plant are most satisfactory. Our longest continuous run to date was made from 5.15 A.M. November 24, to 1.50 A.M. December 4, 1907, 235¾ hours; the plant had been in operation since November 2 and the stop was made for the purpose of cleaning the mixing valve and changing igniters, which occupied two hours. This was not planned in any way as a record run; our engineer assures me that it was not absolutely necessary to stop when he did, but we had shortly before this been troubled with dirty gas, and we were curious to note what effect,

if any, had been produced by increasing the amount of shavings in the cleaner. Much to our satisfaction it had proved to be of great benefit. Our plant is now running 24 hours a day, and we are pumping 1½ million gallons with a coal consumption of 1 100 pounds. The record for yesterday was 62 440 revolutions; the total head, including suction lift, was 108.4 feet; coal fired, 1 085 pounds. This gives a duty of 107.6 million foot pounds per one hundred pounds of coal. The cost of coal per ton was $4.67. The cost of coal per ton used at the steam plant is $5.50, so that in order to compare the efficiency of the two plants on a basis of dollars and cents, it would be necessary to add nearly eighteen per cent. to the duty of the gas plant, which will bring this duty up to 126.6 million. While no test has been made at the steam plant, my belief is that its duty will not exceed 40 million, so that fuel cost of pumping by steam is three times that of pumping by producer gas. During the test of the producer gas plant its duty per one hundred pounds of coal fired exceeded 135 million.

I desire to call your attention now, if I have not before, to the fact that we are pumping against but 110 feet total head, while the unit is designed to work against from 160 to 170 feet total head, which it did during the test above mentioned; also to say that while the engine is now running under a little more than half load, the duty would be materially increased were it running up to rated capacity.

And now, gentlemen, I feel that to say more in this paper may be needless. I reiterate what was said in the beginning, that much can better be told than written, and I renew what I assure you was a hearty and genuine invitation.

DISCUSSION.

Mr. E. H. Gowing.* Mr. President and gentlemen, my experience with this plant would not incline me to hold to the old-fashioned steam engine — for a small plant. It seems to me that the duty they are getting right along every day with a little over half load shows that the fuel cost of pumping water with a gas-producer plant is very much less than with a steam plant, — that

* Civil Engineer, Boston, Mass.

is, the kind of steam plants which we put in for a 1 000 000 gallon plant through New England.

If I were to put in another plant for myself for pumping water, or if I were to build a small electric power station, I should, I am sure, put in some kind of a producer gas plant. I know that neither Mr. Thomas or the officers of the Hingham Water Company would take that plant out and replace it by any such steam plant as is ordinarily put in for that purpose. Of course, if one had to install a 10 000 000 gallon plant or larger, one could get equally good results, equally high duty, from a steam plant, and perhaps might prefer to put in steam, that is, bearing the evils that we have, rather than flying to those we know not of. You will get the idea if I don't quote it just right. [Laughter.] I have had some experience with internal combustion motors for pumping water. We have two at Cohasset, and two at Scituate. They are small motors, the largest about 16 horse-power and, I think, too small for producer-gas plants. Our experience in both places has been very satisfactory as far as the cost of pumping is concerned, and that is what we are looking for.

I do not feel like discussing this thing because I hardly know what to say. If anybody wants to ask any questions, either Mr. Thomas or myself will try to answer them. [Applause.]

THE PRESIDENT. I should like to ask Mr. Gowing what he considers the limit of these gas-producer engines.

MR. GOWING. Which limit, up or down?

THE PRESIDENT. The limit as regards large size, I mean.

MR. GOWING. Oh, I don't know. If I were going to put in a pumping plant up to 100 or 200 horse-power, I think I should put in producer-gas, and probably divide it up into as many units as seemed best, so that in case of breakdown I would not be left without some power; in fact, for a 200 horse-power plant, I should like to have three 100 horse-power units and then I would be sure of having 200 horse-power all the time.

The upper limit I don't know much about. I understand that there are some very large producer-gas plants which are doing well.

I think producer-gas is used more in the territory west of the Hudson River than east of it. In regard to such things New England water-works men are a good deal like New England railroad

men; improvements in railroads usually start in the West and move East. This is a matter which is received with more favor in the West than here.

MR. FRANK A. BARBOUR.* In 1906 the town of St. Stephen, N. B., in connection with the new water supply, installed a gas producer plant exactly similar to that described by Mr. Thomas, but of a larger size. The installation included two producers, each of 135 horse-power nominal capacity, two engines of 125 horse-power nominal capacity, and two triplex double-acting power pumps which, running 32 revolutions per minute, have a capacity of 1 800 000 gallons each per twenty-four hours.

The fuel available in St. Stephen is Nova Scotia bituminous and American pea anthracite, obtainable at practically equal cost of about $5 per ton. The choice between a steam and gas-producer plant was made dependent on actual propositions on both types, bids being called for under the same general specification, with a requirement that bidders should guarantee a station duty, including banking and all standby losses, these to be determined by a three-day test with the engines running eight hours each day and banked the remaining sixteen hours. It was considered that a test of at least this length was necessary to get results of any value from the gas plant, and also that such a test would be the best practical expression of the actual commercial value of the plant. It is to be noted that the inclusion of the banking charge in the duty made the comparison more favorable to the gas producer, as the latter type of plant can be banked with but a small fraction of the fuel necessary for a steam plant of equal capacity.

Propositions were received from two builders of steam plants and from three builders of gas plants. The first cost of the steam plants ranged from 50 to 80 per cent. of that of the gas plants, but the guaranteed economy was also sufficiently lower to make the gas plant the more economical proposition. The work was awarded to the Olds Gas Power Company at a price, including producers, engines, pumps, and auxiliary apparatus, equal to about $100 per horse-power of engine, including the customs duty into Canada. As the engines are larger than necessary for the work of the pumps it may perhaps be reasonable to estimate the

* Civil Engineer, Boston, Mass.

cost per horse-power of such a plant at about $75 in New England.

The duty guaranteed was 115 000 000 foot-pounds per 100 pounds of pea anthracite coal, having a thermal value of 13 000 B. T. U., with not to exceed 10 per cent. ash nor 2 per cent. sulphur.

During the early days of trying out this plant the same troubles as described by Mr. Thomas were encountered, and a better description of the trials which any one will almost surely meet in getting acquainted with producer operation could not be presented. Unquestionably there are in this work more factors each of which may affect results and which demand consideration than with steam work. Any one can boil water without burning it, while relatively few men have any inherited knowledge of the processes necessary to the making of gas of a certain character. Operators for steam plants can easily be found who will readily make them go, whether economically or not being another question; while in producer work the apparatus must be handled about right in order to run at all, but if it goes it runs with good economy.

The difficulties encountered are usually confined to the producer end of the plant or in the making of the gas. The engine troubles, if any, are largely mechanical and readily corrected by the average mechanic. Because knowledge acquired by experiences such as those described by Mr. Thomas is necessary to the successful operation of such plants is no reason to conclude that the element of reliability is lacking. This Association is to be congratulated on the presentation of this valuable paper, but there is also a danger that incorrect inferences will be drawn from this frank statement of the troubles encountered in the early work, and attention should be called to the fact that, after the preliminary difficulties, the apparatus has worked with success and is to be duplicated in the enlargement of the plant. The experience at St. Stephen was very similar, as, after the early difficulties, the plant was left in the hands of a local engineer who is running it without any trouble, although previous to his acquaintance with this plant he had been engaged on steam work.

I think, further, it may perhaps be due to the builders of the plant to say that until the apparatus was in successful operation they did not expect it to be taken over by the town.

In the test at St. Stephen a duty of 125 000 000 foot-pounds per 100 pounds of coal fired, including banking and all standby losses, and with the water used in cooling and in compressing air for starting and blowing hot charged to the plant, was obtained. The coal was below the contract in thermal value, running about 12 000 B. T. U. per pound. The duty was, therefore, equivalent to 100 000-000 foot-pounds per 1 000 000 heat units.

The small amount of fuel used in banking the producer during the sixteen hours of idleness is notable. During the test this averaged 22 pounds for each generator, or equal to about 3 per cent. of the total coal, or about $\frac{1}{100}$ of a pound per hour of banking per nominal horse-power of generator. During another ten days' run the amount used in banking averaged 52 pounds or about 7 per cent. of the total coal used.

In the test, as in actual work, the ashes and coal lost in stoking from the door above the grate were screened and re-fired. The amount of material so screened depends on the operator, and experience in St. Stephen up to the present time decidedly indicates the economy of re-firing the salvage.

In actual running the plant has developed a station duty of somewhat over 120 000 000 foot-pounds per 100 pounds of coal, although the coal contains about 15 per cent. ash, and the engine is running at less than three-fourths of its nominal capacity. This approach to the test duty in every-day operation is worthy of note. Steam duties are usually based on ten-hour tests, and the average station duty, including banking, rarely exceeds 75 per cent. of the test duty. With producers there does not exist the same chance of running up the test duty by expert firing as in steam, and the result is a commercial economy more nearly equal to that found in the test.

The obtaining of pea anthracite coal best suited to the work is a matter to which considerable attention must be given by those operating this type of plant. The amount of incombustible material or ash in the coal does not seriously interfere with the operation of the generator, but it increases the labor in firing and in screening salvage. Sulphur, however, is an element to be strenuously avoided. As to the ash, it is difficult to obtain pea coal with less than 12 per cent. incombustible material. Analysis of

samples recently collected at twelve different collieries show an average ash of 13.63 per cent., with a minimum of 10.92 per cent., and a maximum of 20.65 per cent. In future contracts it would not be unreasonable to specify that the work shall be done with coal containing not more than 14 per cent. ash. Practically the user of producer plants must take commercial pea coal, as the mine agents will not sell according to specifications. If the coal is obtained from local wharves it usually contains, unless screened, so much sweepings and dirt, that the ash contents will run well over 15 per cent. If specially screened, it of course costs more than the average market price. The best way to obtain suitable coal is to buy direct from some colliery where the ash content is reasonably low and sulphur is known, by analysis, to be not present in dangerous amounts. The recent increased demand for small anthracite has resulted in an increased value of at least $1 per ton for this coal over the prices of a few years ago, and in future it will probably be well, in considering the relative economy of producer plants, to figure on a value of pea coal more nearly equal to that of the larger sizes of anthracite than it has been in the past.

In any particular problem of water-works pumping the choice of plant must rest on the relative cost of fuel, the size of the plant, and certain conditions in the method of distribution. Between the small sizes where heavy oil engines have a field and the larger sizes in which high class triple vertical steam engines are justifiable, the gas producer plant is certainly worthy of careful consideration. Its first cost will be more than that of a steam plant, its floor space practically the same, and its necessary attendance but little different. Its reliability, if properly constructed, is probably equal to steam. What may be the relative depreciation of a gas producer plant cannot perhaps be as yet predicated, but in every-day economy it greatly outclasses all but the highest grade of steam engines.

THE PRESIDENT. Is there anything further to be said on this subject?

MR. S. H. MCKENZIE. Mr. President, I might say for the information of those who come from the central part of Connecticut that in our town of Southington we have a 100 horse-power gas-producer plant which was recently installed by a drop forging concern. The manager took me in to see the plant the other day

and he couldn't say enough in praise of it; he said it was far superior to a 50 horse-power gasoline plant which he had been running, and I might say that it works beautifully.

THE PRESIDENT. Have you any idea of the duty which the plant is developing?

MR. MCKENZIE. I couldn't say.

MR. A. O. DOANE. I should like to ask how long it would take to start up, with the generator and everything cold, to blow up a fire and get it all started. I thought from what Mr. Thomas said it might take a long time to get the fire blown up and get the right quality of gas and everything, building a new fire.

MR. THOMAS. I am unable to answer the question in a manner that would be entirely satisfactory to Mr. Doane, for the reason that our needs have always allowed us to take plenty of time in starting our plant. I said in the course of my paper that we obtained a good test of gas at the generator after blowing the fire for an hour, and there is no reason why, as soon after this as a good test of gas is obtained at the engine, the plant should not be running. Please bear in mind that these conditions refer to starting up the plant after its having been shut down some time, with an absolutely fresh fire and everything cold. When starting up with a fire that has been banked over night we have, in our operating, had everything running in thirty minutes from the time the engineer arrived at the station, and in one or two instances this has been reduced to twenty minutes.

I trust no one will draw the conclusion from the paper that we are in any degree disappointed in our plant; on the contrary, we are altogether pleased. In considering what was best to incorporate in the paper, I selected experiences which should be accurate and interesting, and naturally enough these came during the first season. The operating from which material results was obtained came later and these were summed up in the closing pages of the paper, to which I again call your attention, and by carefully referring to these it will readily be seen what excellent service our plant is giving.

A FEW WORDS ABOUT HOLLOW CONCRETE-STEEL DAMS.

BY CHARLES H. EGLEE, HYDRAULIC ENGINEER, BOSTON.

[*December 11, 1907.*]

Mr. President and Gentlemen: I hardly think that the few words which I shall speak in relation to this subject should be dignified by the name of "paper," which implies that something has been specially prepared for the occasion. I feel a certain hesitancy in addressing this Association on this subject for several reasons, the first being that I am associated with a company whose business is the designing and the building of hollow concrete-steel dams. This is a very personal matter, and being, as you know, naturally of a shrinking and modest disposition [laughter], which has been, I might say, increased by a number of years' experience among you as a contractor [laughter], there is a natural delicacy in intruding upon you a subject with which I am so intimately and personally connected. Then, again, I hesitate because the company of which I have spoken has been very industriously engaged for the past few years in presenting to the public, through its literature, which has been very lavishly sent out all over the country, the principles of design and the methods of construction of this peculiar structure. Also, these methods and these designs have been the subject of a number of engineering and quasi-engineering articles that have appeared from time to time in the engineering papers under the form of paid advertisements.

I hardly know how to present to your mind's eye a picture of a modern hollow concrete and steel dam used for the impounding of water, or used for the creation of power on a stream. I presume that most of the members present are not particularly interested in power dams, but are more particularly interested in reservoir dams. I shall endeavor to draw, as well as words will permit me, a picture of a modern method of constructing for reservoir purposes a concrete-steel dam, such as is now being constructed by the city of Pittsfield.

Imagine, therefore, that the site of your dam has been cleared of brush, etc., and the foundation for the dam prepared, — just such a foundation as you would prepare for an ordinary earth and core-wall dam, the vegetable matter, mold, and muck being removed to reach a solid foundation. This, then, stretching at right angles to the stream across the valley, is ready for the reception of the dam. On this prepared surface is laid a flooring of concrete, not following the slopes of the ground, but being laid in horizontal planes and stepped up upon the slopes as we approach the summit or crest of the dam. Of course, as we step up, the concrete base is gradually narrowed until we reach the top.

This flooring of concrete is thoroughly interlaced with bars of steel. These bars of steel are computed of the proper size for resisting the pressure which will be brought to bear upon this foundation, and the concrete foundation is computed to be of a proper thickness to support the superstructure.

Imagine, then, that this floor has been spread. Upon the upstream side or heel of the dam a cut-off wall, corresponding to the ordinary core-wall, is sunk down through the loose strata until it reaches an impervious stratum, either of rock or of clay, so that the water will not pass underneath the wall. That is the ordinary core-wall construction in any ordinary dam, but in this dam it is placed upon the upstream side of the dam, — made of the best quality of concrete, thoroughly connected to the floor by means of steel reinforcing rods. On the lower or downstream side, at the front of the dam, there is another wall sunk, not to any considerable depth, but far enough so it secures between the walls all of the foundation earth material beneath the floor of the dam. This floor is pierced with holes, which are called " weep-holes," in order that if the cut-off wall should not thoroughly cut off the water, or if it should not be thoroughly connected with the underground and underwater impervious stratum, the water finds instant relief and comes up through these " weep-holes." Also, if there is a leak in the cut-off wall, these " weep-holes " will show where that leak is, and it may be repaired. That is the purpose of these " weep-holes," although I have never yet seen any of them weep.

Upon this floor there are erected piers, or what are technically termed " buttresses," which are the support of the dam proper.

These buttresses are erected parallel to the course of the stream, at right angles to the longest diameter of the floor, and rise from this floor up to the crest of the dam. In the instance of which I speak, at Pittsfield, they will be, at the highest point, 40 feet in height. These buttresses do not rise at the same width all the way up, but at every 10 feet of elevation they are stepped in and gradually narrowed until they come to the top. These buttresses are also reinforced with steel rods, and they are computed so that they shall be of such a size as will resist the crushing pressure of the water that is brought to bear upon the dam.

In the preparation of the floor, proper corrugations or steps are cut to receive these buttresses, and each one of them fits into its own particular place; and they are spaced from 10 feet apart to a somewhat larger space than that, as the structure requires. On the Pittsfield dam they are spaced 12 feet center to center. Upon a very soft foundation they would not be spaced so far apart; upon a rock foundation they might be spaced still farther apart. In one instance which I recall they are 18 feet apart, and in that instance the buttresses expand toward the water-bearing surface of the dam into " haunches," which receive the deck or the barrier proper to the water.

After these buttresses are in position a sheet of concrete is laid on the upstream side covering the buttresses all the way from the cut-off wall up to the top or crest of the dam. This sheet of concrete is thoroughly and completely interlaced with steel reinforcing rods and is made of the very best quality of concrete that is known at the present stage of the art. After this sheet of concrete or deck is laid from the bottom of the dam up to the top, the dam is complete.

You must not understand by this description, however, that all of these different processes are taken up consecutively, as I have explained them. In fact, all of these processes usually are going on at the same time. The excavation for the cut-off wall is progressing, behind that the floor is being laid, still further in the rear the first lift of the buttresses is being put up, and still further in the rear of that the deck is being spread on; so that the dam goes up, as it were, from the bottom to the top in a regular progressive order, and not in the order I have previously explained.

When this dam is completed, if you walk upstream to approach

PLATE I.

DAM AT CAIRO, NEW YORK.

the dam it has the appearance to you, more than anything else, of a series of gigantic horse stalls. (See Plate I.) The front of the dam being entirely open, you walk into the dam under the water. You walk over the floor until you have reached the deck of the dam. The dam is perfectly open to you, you can inspect it in any part, and as you stand there and look up to the height of 40 feet and then realize that between you and the water there is only a thickness of about 2 feet or 27 inches of concrete, and when you look at that concrete and see that it is perfectly dry and perfectly hard, you wonder why people haven't built that sort of a dam before, because it is so extremely simple.

I am not going at this time into any of the calculations or computations that are very carefully made in the designing of this dam; nor am I going to explain at this time why the buttresses are spaced as they are, or why the thickness of the deck should be what it is; but I am merely trying to give you in the few minutes allotted to me a description of such a dam which you can carry in your mind's eye.

This describes only a dam of the open-front storage type, but the principle is capable of so many different variations, and is so adaptable to almost every situation, that a very great length of time could be consumed in the explanation of all its peculiar features. Take, for instance, in this particular dam, the matter of an overflow or spillway. In about the center of the dam, over the bed of the brook, the buttresses on the front or downstream side of the dam are not shaped as are the majority of the buttresses, with a little incline toward the top, but they are shaped in a curve, an ogee curve, and that curve is overlaid with an apron of concrete in the same way that the deck is made. The crest is reduced a couple of feet in height at that point, and you have your overflow or spillway constructed which returns the overflow water directly into the old bed of the brook.

Elaborating that one particular feature, and carrying the apron all the way across the dam, you then have a dam that is entirely enclosed. It has the deck on the back, it has the apron on the front, and such a dam as that is put across a river where heavy logs are being driven, or where there is a large flow of ice when the stream breaks up in the springtime, and those logs, that water,

and that ice are returned to the bed of the stream over this apron which entirely encloses the lower part or front of the dam, the entire dam remaining open within. The fact that the dam is open at all times is a feature that is very commendable indeed, because that space can be utilized for so many different purposes. Take a dam like the Pittsfield dam, which is open at all times and easy of access, those spaces between the buttresses beneath the dam are used for the storage of tools or material. Within these spaces are the gate-chambers, the screens, the valves which control the flow of water to the city. They are all easy of access, and no special or particular gate-house is required. If the dam is used for power, as is the case of a dam in Maine, that part of the dam which is not used as a spillway or overflow for the water is enclosed in the front, there are different floors laid in the buttresses at different heights which are connected by iron stairways; the whole interior of the dam is warmed, is lighted by electricity, and these rooms are used for transformer rooms, for the storage of electrical material, for tools, for coal storage, for work shops, lathes are set up within them, and the whole operation of the maintenance of the dam, all the business that pertains to it, is carried on within the dam itself, even including the office of the works.

Another feature which is commendable in the openness of the interior of the dam is the fact that it is at all times accessible and open to inspection. There is no portion of a hollow concrete steel dam that cannot be visited at any time. We therefore know whether our dam is in good service, whether there are cracks or leaks in it, whether there are any repairs necessary, or whether there is any deterioration at any time. If those things should be discovered, they are very easily repaired; I don't know exactly how, because no repairs have yet been found necessary. But still it is a comfort to know that you can look at your dam inside and at any time you want to.

This interior space, too, in power developments, is frequently used for the installation of hydraulic and electric machinery. You take a dam that is from 50 to 100 feet in height — I recall two at the present time 70 feet in height — in which all of the machinery for the generation of electricity is contained under the roll-way,

under the crest of the dam. One of those dams is located in a very peculiar situation, in a box canyon in the West. There is no situation below the dam for a power house. The river is subject to extreme floods at times, cloud bursts, etc., and all the water that goes over the dam is concentrated into this narrow canyon. There is no place to put a power house, and if a power house could be put there the river would be constricted to such an extent that the house would be in danger of being washed away. Therefore, the whole apparatus is put within the dam itself, and all the water that goes over the spillway goes over the apparatus, excepting that which is carried into the dam for use in generating power. This dam is located so peculiarly that there is no opportunity even of getting the machinery into the power house until the dam is constructed. After the dam is finished and the pond filled, the machinery is floated down to the dam on bateaux and lifted up by derricks which are set in the rock and dropped down into the dam itself, and then installed. Probably no other dam could have been constructed in this peculiar situation, and it was necessary that a dam should be constructed there because there are extensive operations going on in that locality which require power, and coal is from $15 to $20 a ton.

The appearance of an open dam such as I have attempted to describe is best shown by Plate I. Here is a dam built for the generation of power, the two penstocks coming out through the bulkhead of the dam on the lefthand side of the picture, and the front of the buttresses showing that peculiar stall-like effect of which I spoke. When the water goes over the spillway of this dam, of course that effect is not visible. At the time this picture was made, the water was running through the dam, before the pond had been closed.

That brings me to another peculiar feature regarding these dams. As we build them in a river, we leave the lower part of the deck off of two or three or more of these spaces between the buttresses, and when we change our cofferdam and turn the river in the other direction, we permit the river to run through those spaces. You see that in this cut; the water is running through between certain of the buttresses; the lower part of the deck on the upstream side of the dam has not yet been put in place. Now, when the time

comes that we wish to fill this pond and permit the water to run over the top of the dam, those orifices must be closed. Formerly in the closing of a solid dam there were expensive works necessary, in the construction of cofferdams, etc., so that the concrete could be placed in security. But in this instance no such cofferdam is required. The orifices are fitted with grooves in the concrete at the back, and when we wish to close them up we merely construct a wooden gate and drop that gate, which is a series of stop-logs, into these grooves, and we shut the water off from running through the dam. Then we go inside the dam, and behind the shelter of these stop-logs we put in a drainage pipe which takes the water that will come through the little cracks of the logs and will carry that water away, and then within that security we build our forms and put in our concrete and permit the water to rise on the dam while we are doing it. Nothing will disturb the workmen, because they are inside under the shelter of the deck. We have all the opportunity we want, so far as time is concerned, and we can permit the concrete to remain there and set up just as long as ever it wants to, until it becomes as firm as all the rest of the dam is, thereby avoiding a very great deal of expense in cofferdamming and in pumping.

In fact this feature, further elaborated, permits us, as has been done in one or two instances, to build the entire dam all the way across the river on piers, without any cofferdam at all. This practice obtains, however, only when the river is of a moderate depth, one or two feet, and has a rock bottom. Under those circumstances caissons or piers are built and filled with concrete and brought up one after the other to above the level of the water, the river continuing to flow all the time. We have then a series of what appear to be stepping stones all the way across. Upon these stepping-stones scaffolds are erected and the superstructure of the dam is carried on, the river meantime continuing to flow underneath the dam. When the time comes to close these orifices, to stop the flow of the river, they are taken up one after the other, stop-logs are put down, and they are masoned up or concreted up from the inside.

The dam as it appears to you seems to be a very slight and skeleton-like structure as you approach it. The buttresses are

not very thick, about 2 feet, as I remember it, at the bottom, on this Pittsfield dam, which is 40 feet high; but as you approach nearer to it, get close to it, and within it, it has an entirely different effect upon you, particularly if you go within a dam that is entirely closed, both on the upstream and downstream side, having a complete deck and apron. The appearance of a massive structure under those conditions strikes you at once. It seems as though it was almost impossible that anything could occur that would affect the solidity and the permanence of that structure. It is necessary, however, very frequently that the permanence and stability of the structure should be well demonstrated in advance, before the structures are built. It will not do to say in many instances that this is so-and-so and it is so because I say so. That is a very bad attitude to assume when you are endeavoring to show to a person any new feature or any bold engineering, and *this is* bold engineering. Therefore the most minute and intimate calculations of all stresses and strains and compressions and pressures of all kinds are made upon each individual dam before anything is ever done in the perfection of its design. That is a feature that it is impossible to speak further of at this time. But there is one feature that is very frequently spoken of that ought to be brought to your attention, and that is the impermeability of the concrete which is used in the barrier to the water—the deck of the dam.

This deck is placed at an angle to the perpendicular, shown, in Fig. 1. This shows a full deck and apron dam, and is built on the Battenkill River. I want to speak to you about the angle that the deck presents to the water. That is the same principle that was used by our forefathers in the building of their old-fashioned wooden dams. There is nothing new about that. I believe that the beavers are still continuing to build that same kind of a dam. But the angle that the deck makes from the perpendicular is adjusted to each different problem as it is presented. This one shows that the angle of inclination from the perpendicular is about 45 degrees, or 1 to 1. Had that dam been built upon a soft bottom, requiring a floor, that angle from the perpendicular would have been greater, probably 52 or even 55 degrees, or an incline of 5 to 4, in order that there might be more pressure brought

in a perpendicular direction upon the foundation supporting the dam. It depends altogether upon what sort of a foundation is underneath a dam as to what the angle of the deck should be, and that is always the subject of very close computation. Also the thickness of the floor of a dam is computed to resist the pressures that are brought to bear upon it.

I have digressed somewhat from what I was going to speak about in relation to this deck, and that is the impermeability of the concrete which constitutes it. When this dam was first brought to my attention, and I looked into the designs, I said at

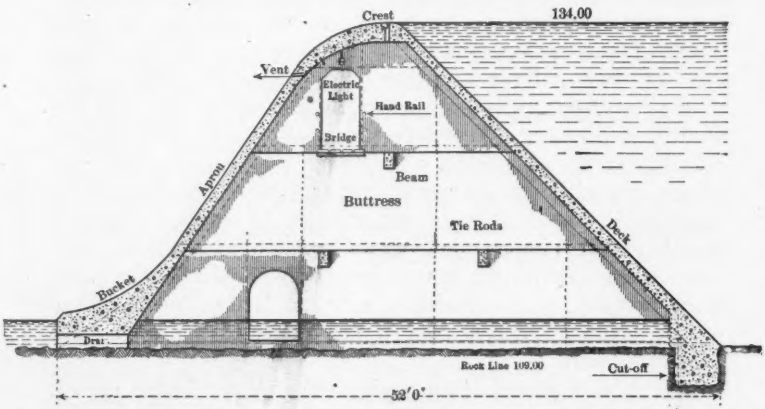


FIG. 1. SECTION OF HOLLOW CONCRETE-STEEL DAM.

once, "The whole thing is a failure; there is no necessity of going very much further into this thing because the deck will leak. Eighteen inches or two feet of concrete will not resist the pressure of water that is brought to bear upon it." And the representative of this company said to me, "How do you know?" "Well," I said, "in a modest way, for twenty-five years I have been putting in concrete; I have been putting in concrete as a contractor, to be sure, but sometimes we get in very good concrete. [Laughter.] In fact, some of the engineers with whom I have been employed have been very highly complimented on account of the concrete which I have put in. [Laughter.] And I know that two feet of concrete

is not enough. Why, the Metropolitan Water Board, when they wanted to hold 15 feet of water, put in a wall of concrete 7 feet thick, and then they weren't quite sure." Well, the president of this company said to me, " You remind me of that old story about the man in jail, whose lawyer told him they couldn't put him in jail for the offense for which he was committed; and the man said, ' Well, it don't make a particle of difference about that, I am *in*. ' " He didn't know how old the story was when he told it to me; if he had he wouldn't have told it; but it illustrated the case, because they *were* putting in the concrete, and I went and looked at it and it was a fact. And when I took my handkerchief out, in the interior of the dam, to wipe off the moisture from under side of the deck, it wiped off dust. There wasn't any moisture. That is a sure test. The concrete in the decks of hollow concrete-steel dams, well put in, mixed with fine aggregates, with plenty of cement and rather an overplus of water, more than is required for crystallization, — such a concrete as that will not leak.

Many have asked whether in the treatment of the deck of this dam there is any special preparation used. Nothing whatever is used. There isn't even a coat of plaster put on the water surface of the dam.

One great help, however, to the impermeability of concrete, which has lately been discussed, is the chemical action that takes place in concrete when exposed to water. The free lime in the cement is formed into carbonates by the action of the water in all the little minute voids which necessarily exist in any concrete, an action being set up exactly similar to the formation of stalactites in a limestone cave; and all these little minute voids are in time filled up with strong carbonates of lime. The water never penetrates beyond these, and this action is begun at the time that the water is brought in contact with the concrete surface and continues up to the time that all the voids are entirely filled. These carbonates of lime will not fill large voids. There must be no large voids in the concrete; the voids between the stones must be filled with the sand and with the cement, and the concrete when mixed must be mixed very wet. If you will notice in the mixing of concrete, where you use an overplus of water, the free water will run out from the forms, but it will not carry the cement with

it; it runs clear from the top, almost as clear as clear water; there is very little sediment. It is a strange thing how much water is required in the crystallization of concrete. There is very little, if any, absorption of moisture by the atmosphere. When you put concrete into a form and allow it to set, you take the form off and you find that the concrete is at the same level that it was when it was put in very wet. There has been no shrinking, at least no appreciable shrinking, although there is undoubtedly a slight shrinking which is carried on from that time until the concrete has got its formal and final set. It is perfectly wonderful how concrete put in in that manner, with due care and with fine aggregates, will resist the penetrating action of water brought to bear upon it under a pressure.

I was told I might speak just so long, and I find I have spoken two minutes over time. If there are any questions that may come to your minds in relation to this matter, for there are very many points upon which I have had no opportunity to touch, I should be very glad to endeavor to answer such question as you may wish to ask.

DISCUSSION.

THE PRESIDENT. Mr. Eglee inquired how long I wanted him to speak, and I asked him how long he could talk on the subject. He said two weeks. [Laughter.] I told him we would try 40 minutes. The subject is now open for discussion, and I think Mr. Eglee will be very glad to answer any question which may be asked.

MR. COGGESHALL. I should like to ask Mr. Eglee if it would be possible to build a reservoir on this principle.

MR. EGLEE. There has been a reservoir built in Waltham, lately, on the principle of a reinforced concrete-steel standpipe, 100 feet in diameter and 40 feet in height. I had the misfortune to build a standpipe of that character some few years ago, and when I finished it it was not tight, and it has never been tight since. There was one built for the city of Attleboro also. That, when built, was not tight, but the reasons for that were many and varied. They had nothing whatever to do with the concrete, which in both instances was of a very acceptable quality. In the instance that I cite, where I built a standpipe of that character, I believe that the problem was altogether too new in the mind of the contractor

and engineer, and it certainly was too new in my own mind, and I have always thought the fault was in the design. I believe that the fault in the Attleboro standpipe was more in the instability of the forms retaining the concrete than in anything else. They were permitted to slip once or twice.

We have designed several reservoirs, to be placed on an elevation, in which there was a floor laid, and on this floor a structure built exactly similar to the one I have been endeavoring to describe, — not round, but coming together at angles. I think the ones we designed were octagonal in shape. The principle was exactly the same. Let me say here, too, that the difficulties in the computations of a structure of that character are almost nothing compared with the difficulties of design of a regular standpipe. The difficulties of design and computation necessary in a dam of concrete-steel are as nothing as compared with the difficulties in computation and design of an ordinary concrete-steel building, which is put up every day.

MR. SULLIVAN. I am a little curious to find out what effect expansion and contraction has?

MR. EGLEE. I am very glad you have touched upon that point. The hollow concrete-steel dam is not a monolithic structure. It resembles, perhaps remotely, a house of cards. It does not fall down that way, but it is put up that way. Each buttress is divided at certain points; and the floor is divided at certain points; the deck is divided in horizontal spacings of 30 feet in small dams, and in large dams every bay (the space between the buttresses) is divided in construction. All these joints made throughout the dam are for the purpose of expansion and contraction. There is a movement in every dam; it does not make any difference how it is constructed, whether it be of masonry or of solid concrete or of concrete and steel, there is a movement due to expansion and contraction. I think if there was any one here from New Haven at the present time he would be able to give an instance of temperature cracks that have already appeared in the new solid concrete dam which was built there this season. The hollow dam, however, takes care of that expansion and contraction by these expansion joints which are left in the dam for that purpose.

MR. MCKENZIE. I understand that you do provide an expan-

sion joint in the decks once in 30 feet; that is, that the reinforcing rods do not cross that expansion joint, but are separated entirely at the ends.

MR. EGLEE. Yes, sir. If the buttresses are spaced, we will say, at 10 feet, then when the deck is put on it covers three buttresses and stops in the center of the third buttress. The next section of the deck covers 30 feet from that. There is no particular expansion joint made there; the work merely butts up to that and stops; the steel stops at that point, and there is a corrugation made, or a rabbet made, in the deck concrete at that point; and when the next section of the deck is put on the new concrete fills up the rabbet. That joint opens and closes. It is perceptible. If the concrete is laid in very hot weather, in the middle of the winter you can put your finger in the cracks.

MR. MCKENZIE. You consider that 30 feet is the proper distance between the joints?

MR. EGLEE. It isn't always 30 feet; it depends on the thickness of the slab of concrete. In dams which are lower than 40 feet in height, we have determined that 30 feet is the proper distance for the expansion joints; at Pittsfield the distance is 25 feet, covering two buttresses.

Mr. MCKENZIE. I noticed in the New Haven filtration works, while there were no expansion joints, that once in about 14 to 18 feet it pulled open, even where the rods crossed, so that there was an opening of perhaps one sixteenth of an inch.

MR. EGLEE. That is very true. That pull is very perceptible. I can cite an instance of that in a certain dam in Vermont, where for some reason or other there were two steel rods which projected from one of the buttresses into the deck. There was an expansion joint which came upon that very buttress, and one of these rods was in the deck on one side of the expansion joint and the other rod was on the other side. The pull from contraction was strong enough to split the buttress vertically between the rods, and the deck opened just about as wide as my finger.

MR. MCKENZIE. May I inquire also if you have not thickened up the concrete on the deck and on the apron from the original plans or from your practice of two or three years ago?

MR. EGLEE. Yes, sir. We have thickened the concrete on the

deck and the apron of the dam as a concession to public opinion. There is no necessity for a thickness of that kind, but it is very difficult to convince the building public that there is not such a necessity. We are also in such a position that we cannot make our buttresses as thin as the computation calls for. We put in a surplus quantity of material in the buttresses, but we save concrete by cutting out large openings in the buttresses.

MR. MCKENZIE. May I inquire if you have not also increased the thickness of the concrete outside of the reinforcing rods; that is, originally weren't they about 1 inch in from the outer surface, whereas now they are at a greater depth from the outer surface?

MR. EGLEE. That is caused by a difference in construction, merely. We want to put our reinforcing rods as near to the lower side of the deck as possible. The deck is computed as a beam which sustains a certain pressure. That beam rests from center to center of buttress. We therefore want to get our steel reinforcement as low into that beam as we possibly can; so we put our steel within one inch of the under surface. But a difference in construction has shown us that it is wise to drop our deck below the buttress and key it over the buttress a little bit. By doing that we obviate the necessity of building lateral beams between the buttresses. In dropping the under side of that deck 1 inch to give it that lap over the buttresses, it has made the steel 1 inch nearer to the water surface, and we have put 1 inch more concrete on on that account.

MR. MCKENZIE. What is the average depth from the surface of the concrete to the outer side of the rods in the deck and apron?

MR. EGLEE. That is a difficult question to answer. I can say that at the top, near the crest of the dam, usually the depth is 10 inches, unless the dam is in a river subject to heavy ice runs. In that case it is thickened considerably. In a water-works dam, like the reservoir dam at Pittsfield, I think the distance is 10 inches. The thickness increases all the way down to the bottom, depending upon the height of the dam.

MR. MCKENZIE. I had more particular reference to the matter of the penetration of the water and to the corrosion of the rods with respect to the depth that they were sunk in the concrete.

MR. EGLEE. I am glad you have brought up that question of corrosion of the rods. There is no corrosion of the rods. That has been demonstrated in various ways. In the first place, the rods are very close to the inner edge of the concrete. There is nothing shows more distinctly on concrete than rust. If water penetrated through that concrete and attacked those rods, the pressure of the water on the outside would force it through to the inside, and there would immediately be a stain of rust there. There is a stain of rust everywhere that we put a bolt through the concrete. We put bolts through the deck at the buttresses in order to hold our false work, our forms, and we set those bolts in a gas pipe in order that they may be removed. Every one of those gas pipes streaks the concrete with rust. It is not necessary to let the water rise; the very first rain will do that. If the water penetrated into the concrete and attacked those rods, we would know it immediately, because the rust would stain the inside.

Another proof that the rods are not attacked by the water is that there is no moisture on the inside of a dam excepting the moisture from condensation from the atmosphere. On a clear, crisp, dry, windy day there is no moisture on the inside of a dam; on a warm, muggy day there is always moisture dripping from the inside of the deck, caused by the coolness of the water on the outside.

MR. D. E. MAKEPEACE. I should like to state with regard to the standpipe in Attleboro, that it is absolutely tight and has been so for a long time.

MR. EGLEE. I beg to apologize, sir. I ought to have said that at the time of my last information, which was gathered at the time of the reading of the paper on the Attleboro standpipe, at the Annual Meeting at the White Mountains, the Attleboro standpipe, according to the statement in the paper there read, was not tight. And the reason which I have given for that, viz., some irregularity in the building of the forms, is what I gathered from the same paper. I am glad it is tight.

THE PRESIDENT. Mr. Winslow, how is it about the Waltham standpipe?

MR. WINSLOW. I don't know that Mr. Eglee said that that leaked.

MR. EGLEE. I think I should have said that the gentleman who built that standpipe informed me that it was absolutely and per-

fectly tight; that there never had been a repair of any character whatever upon it, and that it was a very satisfactory piece of work.

MR. RICHARD A. HALE. I should like to ask Mr. Eglee if any special provision has been made in the form of the dam on large rivers like the Merrimac and Connecticut, where there is very heavy ice and where large quantities of logs frequently come down. Take it at high water in the Merrimac, ice is often two or three feet in thickness, and sometimes a boom of logs breaks away and comes down, and there is a great deal of trouble at the dam. I would like to ask whether special provision should not be made in the construction of a dam on such streams.

MR. EGLEE. Yes, sir. Special provision is made for the protection of the dam always. There is a dam built on the Missisquoi River, at Sheldon Springs, Vt. Before that dam was built, three dams had been carried away on that site within the previous seven years by ice gorges. The river there is very much constricted. The ice forms and comes down with a solid impact against the dam. To avoid that the deck of the dam is broken in its angle, and instead of going straight up from the bottom to the top like that, it goes up this way [illustrating], and then there is an easier slope which catches the ice and conveys it over the crest of the dam; and the same with logs. When the logs or the ice have gone over the crest of the dam, they are received by the apron and delivered upon a bucket. That bucket returns them to the river in as nearly a horizontal plane as can be computed. The ice and logs come down there very swiftly and heavily and strike on that bucket with force, unless there is a water cushion; therefore that bucket is made deeper and thicker and is very solid, computed to the necessities of the case.

I have spoken in my illustration of a dam 40 feet in height. When these dams were first being constructed it was presumed that when we reached a height of 25 or 30 feet we had reached the limit. Dams, however, are now under contract 100 and 150 feet in height on this same construction; and studies have lately been perfected for the government — which studies they do not expect to use, but they wish computations for — for this class of work under a head of 300 feet.

PROTECTING WATER PIPES FROM FREEZING.

[Topical Discussion, January 8, 1908.]

THE PRESIDENT. I want to ask some of the members to tell me what is a good, practically indestructible, cheap packing for water pipes over bridges. We have a case in Newton of a fairly long line of 16-inch main crossing a bridge, through which the flow is rather sluggish. If it wasn't so, we would probably leave the pipe as it is; but we are rather fearful that in severe weather the pipe may possibly get caught. We don't wish to use anything that is very expensive, and we don't wish to put in something which will rot out within a few years. I felt sure that I would get a suggestion from some of the members here to-day.

MR. R. C. P. COGGESHALL. I think I can say something, Mr. President. We have a bridge which connects our city with Fairhaven, which is located on the opposite side of our river. A few hundred feet from the New Bedford shore this bridge passes across a small island. The water between the New Bedford shore and this island was formerly the ship channel and here a draw in the bridge was located. Formerly, this island was supplied by a 2-inch lead pipe laid across the bottom of this channel. We had frequent trouble with it on account of freezing, which we attributed to anchor ice. This bridge was replaced by a new structure about five years ago, and as the draw was then located in another section, it was not necessary to longer continue the siphon to supply this island. Accordingly, a 6-inch pipe was laid upon a platform passage-way suspended from the bridge beneath the floor. This pipe was tightly covered with double boxing, with an air space between the two. This was done in 1902. We have had some severe winters since, but no trouble from that pipe. I thoroughly believe that a good "air space" is the best preventive of frost action.

MR. FRANK L. FULLER. Mr. President, I agree with Mr. Coggeshall. I have laid pipes over bridges in a great many instances, and double boxing has always been sufficient to prevent

the pipe from freezing. When we built the Wellesley works, we thought we would pack the pipe with tan-bark, but that soon became saturated with moisture and froze up solid, and I think that same winter, on account of the freezing of this mass of tan-bark around the pipe, the pipe also became frozen solid. I think we have had one or two cases where with double boxing and an air space the pipes have caught, but the pipes never have been frozen sufficiently to burst; and I think that where the circulation is at all good that is sufficient. In the place that is spoken of by the president, possibly still another boxing would be an additional protection. I am sure from my experience that an air space is much better than it is to put any substance around the pipes.

ONE YEAR'S PRACTICAL EVERYDAY EXPERIENCE WITH AN AUTOMOBILE FOR BUSINESS, BY A WATER-WORKS MAN.

BY F. F. FORBES, SUPERINTENDENT OF WATER WORKS, BROOKLINE, MASS.

[*Read January 8, 1908.*]

When, in December, 1906, it was proposed to procure an automobile for the use of the superintendent of the water department, the writer must confess that he had some misgivings as to the economic results which might be expected from the every-day use of such a machine.

One member of the water board in particular had had some experience with automobiles, and he was of the opinion that it would be for the benefit of the Water Department to own and operate an automobile, and his ideas in the matter received the hearty approval of the other members. The selection of a machine which would give the town the best service for a moderate outlay was not an easy problem to solve. After the usual preliminary work of looking over numerous catalogues and pamphlets gotten out by different manufacturers of automobiles, each one, of course, claiming that his machine was the best in the market, and personally examining different machines, the board decided to buy a 10 horse-power Cadillac runabout.

The price in Boston, including horn, lamps, and a few repair parts, was $794.00.

The results which have been obtained by one year's use of the automobile have been eminently satisfactory. It has been my custom to take the machine from the stable, where it was kept in the same building with the horses and wagons, every week-day morning and not return it to the stable necessarily until evening. If I spent one or more hours in the office, the machine was outside ready for immediate use.

At noon it was not necessary to feed it. The frequent calls here and there which all of us superintendents have could be made

in one half or perhaps one third the time required by a horse for motive power. I am very sure that two horses could not have done the work performed by our automobile during the busy months of the past season.

There is the further advantage that an automobile enables a superintendent to see more of the work under his charge and see it oftener, and also allows him more time for office duties. In fact, in my opinion, an automobile adds greatly to the efficiency of a superintendent.

An illustration of the time saved the writer on one day of each week can well be mentioned. On Monday it is one of the writer's duties to pay the men of the department, and he improves the time for an inspection of the pumping stations, the grounds around them, etc. The distance from the town hall is about seven miles — an hour's drive for a horse which is used every day, but an easy ride of twenty minutes with an auto, a saving of time in one half day of one hour and twenty minutes.

Perhaps some one will ask, How about all the delays caused by breakdowns, etc.? In reply I will say that in my opinion there is no more need of a breakdown or delay with an auto than there is when using a horse and wagon. During the whole of the past year, during which I have ridden over five thousand miles, I have not had one breakdown or delay of any account, and my automobile has never failed to bring me back to the stable on time with its own motive power at the close of the day's work.

It is particularly useful for night and Sunday calls. No horse to harness, but simply give a turn to the engine, jump into the automobile, and away at a speed of 20 or 30 miles per hour, provided, however, the police are not in sight, in which case a more moderate speed is advisable.

A few words in relation to the care of the machine and cost of maintenance may be of interest. Our stable man fills the tank with gasoline each day, usually in the morning, and sees that the oil and grease cups are full, and does the necessary washing. I have always made it a practice to examine the machine carefully once each day to see that the oiling devices are working properly and all the mechanical parts are in adjustment and repair. The tires will probably give one more trouble than anything else.

I always carry extra inner tubes in my automobile, as no one knows when a puncture may occur. I have been as long as three months without getting a puncture. The time required to replace an inner tube is about one-half hour, and after one knows how it is not a hard operation. The shoes, or tires, will last for a distance of from 3 000 to 5 000 miles, depending a good deal on the quality of the rubber in the shoes. I have worn out one set.

All must realize, however, that an automobile is a machine, and a rapidly running one at that, and consequently must receive the intelligent attention due all such mechanical devices. It is vitally important that all moving parts be kept well oiled and in good adjustment. For one who has some natural ideas of mechanics and is interested in mechanical matters this is not difficult or unpleasant and does not require much time.

The length of time required to learn to operate an automobile at slow speed need not be more than two or three days, but to feel as much at home behind the wheel at all speeds and in all places and act as mechanically as one does when walking, requires not less than four months of constant operating — at least, such has been my experience. It is a fact that one will learn little things about the machine nearly every day.

The maintenance of the automobile for twelve months has been as follows:

Repairs and extra parts	$58.18
Lubricating oil, 30 gallons	19.00
Gasoline, 330 gallons	71.15
Tires	113.40
Batteries and miscellaneous	9.68
Total	$271.41

In addition to the above expenses, it is necessary to have the machine carefully overhauled and painted once every year. This we find will cost from $75 to $100. The depreciation of the machine, supposing that at the end of four years its economic usefulness will end, will be $200 per year, making the total cost for one year $571.41. This amount gives a cost per day of $1.56.

It seems to the writer that, taking everything into consideration, it is greatly to the benefit of any water department, except

small ones, to use automobiles. The price per mile, about eleven cents, is less than the cost per mile when horses are used, and the saving in time is certainly an important item and in many cases worth more than the entire cost of operating the machine.

DISCUSSION.

MR. DEXTER BRACKETT.* I can say that the conditions on the Metropolitan Water Works are good, if not exceptional, for the use of automobiles to good advantage. From the limits of the Wachusett watershed in Princeton to the limits of the distribution system the distance is over seventy miles, and the distance across the district supplied with water is 20 miles. An inspection of the reservoirs and aqueducts, on account of the long distances, can be very greatly facilitated by the use of an automobile. I have used one on the work for four years, and there are now three machines of different makes in use on different parts of the works. Taking into consideration the saving in labor on account of the additional work which can be accomplished, there is, in my opinion, no doubt that they are a very valuable addition to almost any water-works plant.

As to the expense of operation, our experience has been that a light runabout operated almost constantly excepting during the winter can be expected to do good service for about three years at a cost of about $600 per annum, including first cost of the machine as well as repairs and supplies. The cost of repairs and supplies on the different machines has been from $200 to $450 per annum. As to the reliability of an automobile, much depends upon the care given to see that it is kept in good order. When I start on an all-day trip with a definite timetable I am very seldom delayed by the breaking down of the automobile. The only delay during the past season in riding between 4 000 and 5 000 miles, due to the automobile, was one of twenty minutes caused by a punctured tire.

MR. WM. F. SULLIVAN.† Mr. President, I agree with Mr. Forbes that the Cadillac is the best machine made, because I happen to have one this year. [Laughter.] In regard to breakdowns, we never had a breakdown; the only time it ever balked was when I

* Chief Engineer Metropolitan Water Works, Boston, Mass.
† Superintendent Pennichuck Water Company, Nashua, N. H.

had a hoodoo from this Association with me, a gentleman from the Builders' Iron Foundry. [Laughter.] The machine ran 2 300 miles to October 1, and it never failed to come back. We have never been "towed in." In addition to the usual work, our emergency man uses it for "hurry calls," and at night in answering alarms for fire.

We supposed that the overhauling was to be done by our engineer at the Pumping Station, but no such work has been necessary up to the present time. We reckon it is a great time saver because it gives us an opportunity to use the time usually consumed in going the rounds with a horse for other things.

I have here a few figures in regard to the cost of investment, and the economy of the automobile, that one of my friends wanted. The total cost of Cadillac (runabout) automobile, including top, lights, horn, gas tank, and 120-gallon Bowser gasoline storage tank and pump, was $1 084.98. For the maintenance of it last year we paid for gasoline, $25.14; cylinder oil, $4.35; grease, 20 cents; spindle oil, 30 cents; repairs on tires, $19.55; sundries, $1.65. The total expenditure was $51.19. Total mileage was 2 300. The cost per mile, $0.022. The mileage per gallon of gasoline, 17.7.

THE ACTION OF WATER ON PIPES.

BY FREELAND HOWE, JR., CHEMIST AND BACTERIOLOGIST, NORWAY, MAINE.

[*Read January 8, 1908.*]

Scope of Paper

It is the purpose of this paper to treat of the causes, extent, and results of, and the remedies for the action of water upon pipes.

The subject is one of great importance and one which is not fully understood. Recent chemical research seems to throw new light upon the whole matter although the researches to which I refer present no really new theories, but furnish evidence substantiating principles which are clearly set forth in modern treatises on chemistry. The principal researches to which I refer are:

New Light on Action

First. "The Corrosion of Iron," by Allerton S. Cushman, Washington, 1907.

Second. "The Corrosion of Iron and Steel," by Wm. H. Walker, *et als. Jour. Am. Chem. Soc.*, September, 1907.

Third. "Ionization of Water," by C. W. Kanolt. *Jour. Am. Chem. Soc.*, October, 1907.

As stated, the facts developed in these studies furnish confirmatory evidence to the principles of chemistry as given in modern works. In a trade publication which I wrote two years ago for the Pittsburg Filter Manufacturing Company, I ascribed the action of water on pipes to the same principles which these researches confirm.

Extent and Result of Action

Water pipes have been so extensively and seriously acted upon by the water which they convey as to cause the water to produce disease and death; water supplies to be abandoned and new ones sought; bursting of water pipes and failure of water pressure; complete replacement of considerable lengths of pipes; and to render the water unfit for drinking, washing, and various other purposes. The extent to which the action can go under certain circumstances is almost without limit and is dependent upon the

conditions under which the action takes place. For these reasons the subject is one of great interest to all who are associated with water works.

There are important questions constantly arising as to what kinds of pipes are best adapted to certain kinds of water. Some waters affect a pipe of one quality while others do not. In many places nearly all metal pipes are seriously affected. The effect which water has upon pipes has been ascribed to various causes, *e.g.*, oxidation, abrasion, corrosion, tuberculation, electrolysis, action of carbonic acid, peroxide of hydrogen, biological activity, etc. There is a great medley of causes to which this action is referred. It is difficult to determine where one process leaves off and another begins. Is there one cause for this action or are there many? What is the exact truth regarding this action? To what extent will the action proceed? Is there any remedy or preventive? All these questions deserve serious consideration.

Problem Stated

For a solution of the problem it is necessary to know:

First, what *water* is; *second*, what *pipes* are; and *third*, what *action* is.

Dissociation

In order to arrive at a full understanding of the action of water on pipes, I consider it necessary to know what *dissociation* is. It is this: Water is made up of two atoms of hydrogen and one of oxygen. It is H_2O. There never has been, is not now, and probably never will be, any absolutely pure H_2O. Distilled water is an approximation to this, but distilled water dissociates slightly to form hydrogen ions (hydrion) and hydroxyl ions (hydroxidion); that is: $H_2O = H^{\cdot} + OH'$. This is dissociation, or one kind of it. Likewise all substances which go into solution in water dissociate to a greater or less extent, *i.e.*, split up into their component parts. Common salt (sodium chloride) dissociates to form its components, chlorine ions (chloridion) and sodium ions (sodion). The products of dissociation are termed *ions* and have properties different from the chemical elements from which they are derived. The dissociation of chemical substances is usually slight, and the weaker the solution the more complete the dissociation. Suppose we start with salt and water. If we put into the water more salt than will dissolve we have this combination, solid salt (sodium chloride), salt in solution, and dissociated salt giving rise to sodium

and chlorine ions (sodion and chloridion). The sodion is different from sodium, which is a metal, and the chloridion different from chlorine, which is a gas. The exact degree and manner of dissociation of all substances does not concern us here, but it does interest us to know that it is only when substances are dissociated into their component ions that they are most active chemically.

It happens that natural waters contain nearly all salts in such a low degree of concentration that they are completely dissociated or nearly so and hence are very active chemically. The quantity and quality of the ions determine to a large extent the action of the water on pipes.

Dissociation of Water

Kanolt, summarizing his own work and that of others working on the same subject before him, gives the following table showing the extent of the dissociation of water.

TABLE SHOWING THE HYDROGEN ION CONCENTRATION ($\times 10^7$) IN PURE WATER. RESULTS OF VARIOUS INVESTIGATIONS.

Investigator.	0°.	18°.	25°.
Arrhenius			1.1
Wijs			1.2
Nernst		0.8	
Löwenherz			1.19
Kohlrausch and Heydweiller	0.36	0.80	1.06
Kanolt	0.30	0.68	0.91

This means that at 0° one million liters contains 30 mg. of hydrogen ions and 510 mg. of hydroxyl ions; at 18°, 68 mg. of hydrogen ions and 116 mg. hydroxyl ions; at 25°, 91 mg. of hydrogen ions and 155 mg. hydroxyl ions. Without exception these quantities are smaller than those in which any elements of water are usually determined in making a sanitary or mineral analysis, and yet they are large enough to cause water to have a decided action toward metals. (*Cf.* Rept. St. Bd. Health, Mass., 1898.) Clark found that distilled water with exclusion of air dissolved 0.77 parts per million of lead in two weeks. Walker obtained similar results. I will defer the detailed interpretation till later. It is merely desired at this point to understand what dissociation is and to what extent it occurs in water — as pure as we can make it — distilled water. On account of its dissociation water can be regarded as either a weak acid or a weak base.

Carbon Dioxide

To a further understanding of the action of water on pipes I consider a detailed knowledge of "carbonic acid" of utmost importance. The chemical formula of carbonic acid is H_2CO_3, but no one has ever had this in his possession and probably never will, for it is, up to date, a hypothetical substance. It is merely a product of thought. Many chemists in the analysis of water determine the amount of "carbonic acid expressed as CO_2" (carbon dioxide). The Maine State Board of Health and Massachusetts State Board of Health do not consider the determination of this constituent of water of sufficient importance to record it in the regular analyses which they make of the public water supplies.

Method of Analysis

The determination for carbon dioxide is usually made by titrating 100 cc. of a freshly collected sample against fiftieth normal sodium carbonate, using phenolphthalein as an indicator. In this titration the reaction is as follows: In the first place the sodium carbonate dissociates or hydrolyzes so:

$$Na_2CO_3 + H_2O = 2Na^{\cdot} + 2OH' + CO_2,$$

which means that the sodium carbonate hydrolyzes to form sodion, hydroxidion, and carbon dioxide (a gas). Hydroxidion will form a chemical union with phenolphthalein to produce a compound which imparts to water a red color; but if the water happens to contain hydrion, this hydroxidion will unite with it to form water so:

$$OH' + H^{\cdot} = H_2O.$$

This reaction will take place as long as there is any hydrion left, when an excess of hydroxidion will remain and the pink color showing the end point will prevail.

The equation is usually written:

$$Na_2CO_3 + H_2CO_3 + H_2O = 2NaOH + H_2O + 2CO_2,$$

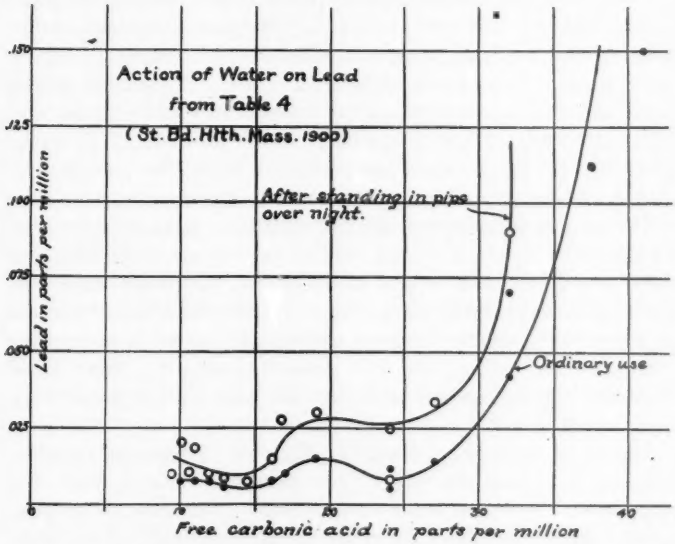
and the results are expressed as parts per million of CO_2. Usually the figures do show the exact number of parts of carbon dioxide present in the water, although this does not enter directly into the reaction by means of which its quantity is determined. The proper equation is:

$$2Na^{\cdot} + 2OH' + CO_2 + H^{\cdot} + HCO_3' = 2Na^{\cdot} + 2OH' + 2CO_2 + H_2O.$$

What actually happens is that the hydroxidion derived by hydrolysis from the sodium carbonate solution combines with the hydrion to form water. The hydrion is what gives water its acidity and it exists in the water by virtue of the presence of its partner (so to say), carbon dioxide. Its partner might as well be something else, in which case the analysis would erroneously show the presence of carbon dioxide.

The pressure of one atmosphere is fifteen pounds per square inch. Under this condition one liter of water will dissolve, at 60°, 580 mg. of CO_2. Under greater pressure water will dissolve more gas, the amount dissolved at any given number of atmospheres being about as many times as great as there are atmospheres pressure.

The accompanying diagram made from data contained in the 1898 report of the State Board of Health of Massachusetts shows that there is a direct correlation between the amount of carbonic acid present in water and the degree of action on lead pipe.



The new light in which I wish you to look at "carbon dioxide" is this: That while in the majority of cases there is present in a

Significance of Analysis

water the same amount of carbon dioxide as the analysis indicates, the active principle which we determine in the water by analysis is the *hydrogen ion;* that this is what reacts with our chemical reagent, and that we merely assume the presence of the proper amount of CO_2 to allow the hydrion to be in the water. The correlation which the above diagram indicates is due, as we shall see later, to the action of the hydrion and not the CO_2.

Natural Occurrence

Almost every natural water contains some hydrogen ions, *i.e.*, is acid to phenolphthalein. Even rain water may be so. Surface water is still more so than rain water owing to the production of hydrogen ions and their complements in the soil and their extraction therefrom by the running water. Ground water is generally more acid to phenolphthalein than surface water for two principal reasons; first, that this water is longer in contact with the soil; and second, that being under more pressure, it can hold more hydrion and carbon dioxide.

Water a System

In arriving at an understanding of the action of water on pipes it is necessary to know what *water* is. My understanding of what water is may be a little different from that of some others. I understand water to be what chemists call a *system.* A chemical system is a collection of various elements or *components* which are each and all infinitely related to and dependent upon the others. The quantities of *some* components are dependent upon the quantities of others, and *some* cannot exist in the system unless others are there.

A Chemical System

Different Systems

There are many different kinds of systems. Each is made up of an almost infinite number and kind of parts or elements, each and every one of which is dependent upon each and every other one. Each holds its place by virtue of the presence and deportment of all the rest. If one new element enters or leaves a system another one must come to or go from it in order to balance it. The natural tendency in every system is to maintain itself, *i.e.*, to preserve an equilibrium.

A Water System

I speak of *water* as a *system*, *i.e.*, H_2O, the carbonates, chlorine, magnesium, potassium, etc. Each element of the system is a *component.* As in the water-works system, so in the water system, a new element may enter naturally or artificially, and at the same time there leaves a certain other element or elements which results in the improvement or impoverishment of the system as applied to

man's various uses. These analogies might be carried indefinitely, but we have other considerations.

Let us now see of what a typical water system is composed, or what its components are.

Water Vapor

To this end we will start with water vapor which forms by evaporation from the surface of terrestrial bodies of water, from green leaves, etc. This vapor consists of hydrogen and oxygen and is invisible. It may become condensed and so visible in the form of clouds or fog. If condensed it consists of drops of water (H_2O) and in its passage through the air comes in contact with various substances for which it has a greater or less affinity. This water itself becomes dissociated, as before explained, both from the nature of the water itself and as a result of the action of ultra-violet light. This gives us, to start with:

$$2H_2O = H^{\cdot} + OH' + H_2O.$$

(hydrion, hydroxidion and water.)

This water comes in contact with carbon dioxide (CO_2), a gas present in air to the extent of about one volume in 2 500 of air. This would give us:

$$3H_2O + CO_2 = H_2O + H^{\cdot} + OH' + \overbrace{H^{\cdot} + HCO_3'}.$$

hydrocarbanion, the new element.

Carbon dioxide gas is derived from various sources, among which are natural processes of decay, animal exhalations, and artificial combustion.

Other substances in the air which may become associated with our system are ammonia gas, nitric acid, oxygen, ozone, organic matter, dust particles (consisting of sea salt and many other light substances).

It has been found that 100 volumes of water under a pressure of one atmosphere will absorb the following volumes of gas:

	Oxygen.	Nitrogen.	Hydrogen.	Carbon dioxide.	Carbon monoxide.	Nitrous oxide.	Hydrogen sulphide.	Sulphur trioxide.	Marsh gas.	Ammonia.	Nitrogen trioxide.
0°	4.82	2.35	2.15	179.7	3.54	130.5	437.1	688.6	5.4	104960	7.38
20°	3.10	1.54	1.83	90.1	2.32	67.0	290.5	362.6	3.5	65400	4.71

As a result of contact with all these substances meteoric water may constitute a very complex system, as for example:

$$H_2O + 2H^{\cdot} + OH' + HCO_3' + Na^{\cdot} + Cl' + 3NH_3^{\cdot} + 2SO_4'' + Ca^{\cdot\cdot} + NO_3' + N + O_2, \text{ etc.}$$

Analyses of rain water show all these components present and to such an extent that the amount of solid matter obtained from rain water has been known to be as much as 50 gm. per cubic meter.

Surface Water

This water falling to the ground at once attaches to itself whatever substance it may come in contact with and which by its nature it may take up. Some of the elements already present may be precipitated in the soil or may be taken up by the various plants inhabiting the soil, such as molds, bacteria, mosses, ferns, grass, shrubs, trees, etc. Whatever changes do take place are very complex and it would take more than one lifetime to attempt to solve completely the exchange of elements which takes place here. As a general rule it may be said, however, that surface water contains more dissolved substances than meteoric water, although the reverse may be true.

Ground Water

A new factor which the water encounters in passing into the ground is pressure. Increased pressure allows the water to absorb more of certain elements than when it is under a pressure of only one atmosphere. Whether surface or ground water, the system comes in contact with more metals and salts and has its composition changed according to the geological and climatological conditions which pertain.

It is principally with surface and ground water that we are now interested, and the problems which confront us in studying the action of water upon pipes is wholly dependent on the character and quantity of the components of the system which this water forms.

What Pipes are

Having come to a knowledge of *what water is,* we will ask *what pipes are.* Pipes are of metal (more or less pure): iron, plain or zinc coated (galvanized), tin or lead lined; brass (copper and zinc); lead; block tin; copper; glass; wood; and cement or cement lined. Some pipes have internal and external coatings which prevent immediate contact of water and metal (more or less). These coatings may be imperfect on account of blow holes, scratches, etc. The metal of some pipes is impure, which might

cause galvanic action. Sometimes pipes of one metal are joined by means of another, which might also institute galvanic action.

Pipes then are mainly of metal, and in dealing with the action of water on pipes we have to do principally with the action of water on metals.

Potential Series of the Metals

By experimenting with different substances it has been found possible to arrange all the metals in what is called an *Electrochemical Series*, so that each precipitates all the metals following from their aqueous solutions and is in turn precipitated by each of the preceding ones. This series is also called the *Potential Series of the Metals* and is in part as follows:

Potassium	Cobalt
Sodium	Nickel
Calcium	Tin
Magnesium	Lead
Aluminum	Hydrogen
Manganese	Copper
Zinc	Silver
Iron	Platinum

Characteristics of the Metals

We have in this potential series of the elements an arrangement of the metals in the order in which they are dissolved in water in the greatest quantities and with the greatest energy, and, in a general way, a list of the metals in the opposite order of their degree of poisonous qualities. At one end of the series is sodium, which attacks water very violently, and at the other end is platinum, which chemists find almost indispensible in the laboratory because it is so resistant to all kinds of liquid. Zinc and iron occur in water in greatest quantity, but never enough, so far as known, to be poisonous, while the ions of lead, tin, copper, and silver are all poisonous.

If we have a system containing calcium, zinc, iron, and lead, metallic sodium will precipitate these from solution, *i.e.*, will replace them in the system. They will be converted into an insoluble form.

The metals throughout are characterized in that they receive only positive electrical charges; or they are able to go into solution only in the form of positive ions. The tendency which metals have of going into solution in this way is called the *Solution*

Mode of Action

Pressure and has a definite value for each metal under definite conditions. In order to determine then in a definite way if any system of water with which we have to deal will act upon any of the metals of which pipes are composed, it is necessary to know the nature of the metals and also the nature of the system. A shorter way is to put the two together and determine by analysis if action does take place. But sometimes this is an expensive operation, and even then we are not sure whether the action, if present, will be permanent. It is desirable to have as complete a knowledge as possible of all conditions.

Metals replace Hydrion

How, now, do different waters act upon the metals of pipes? We have seen that hydrogen ions are almost universally present in natural waters and even in distilled water, and we also observe that hydrogen has a place in the potential series of the metals which would allow it to be replaced by nearly all of the metals of which pipes are made, viz., zinc, iron, tin, and lead; and this is exactly what does take place in almost all cases where pipes are acted upon. When hydrion is present in water under proper conditions it will be displaced by any of the metals named and will itself become converted into inactive gaseous hydrogen and escape from the water if possible.

Copper

Copper occurs in the series after hydrogen, which would lead us to suppose that it cannot replace hydrogen. This is true and shows the reason why copper is particularly adapted for water conductors.

Silver

Silver occupies a position in the series which makes it affected still less than copper. This fact is taken advantage of in some cases, *e.g.*, at Poland Springs, Maine, where a silver-lined pump and connections are being built for use in connection with Hiram Ricker & Sons' beautiful bottling establishment.

The following table is prepared from the records of the Massachusetts State Board of Health. It shows that different waters, each acting under the same conditions, affect zinc most, iron next, and lead and tin least. The figures show averages:

PARTS PER MILLION DISSOLVED.

	Zinc.	Iron.	Lead.	Tin.
Fairhaven	9.7	4.7	2.0	0.2
Kingston	4.5	0.05	2.5	0.19
Lowell	5.6		0.4	0.09
New Bedford	5.1	1.9	1.6	0.25
(Time of action, one hour)				
Fairhaven	15.4	9.2	4.0	0.4
(Time of action, over night)				

In the case of zinc and iron, the difference is plain; but there seems to be less tin than lead dissolved, a fact which is of general prevalence. The reason probably is that tin does not form powerful bases; that at ordinary temperatures it does not oxidize, while lead oxidizes easily at low temperatures. Zinc, which is the pipe metal farthest removed from hydrogen, acts most strongly, and iron next. Lead and tin are close together, near hydrogen, and have a less solvent action. Lead oxide is slightly soluble in water and communicates an alkaline reaction to it since it forms hydroxidion.

Apparent Exceptions

That copper is not acted upon by natural waters like other metals is due to two things: *first*, its place in the potential series of the metals; and *second*, that in many natural waters a protective coating is rapidly formed over the surface. That metallic copper does react with water has been demonstrated in the case of the investigations in relation to the sterilization of waters, but here it does not act like other metals. A reduction product of some anion present in the water is formed something like:

Copper

$$3Cu + 8H^{\cdot} + 8NO_3' = {}_3Cu^{\cdot\cdot} + 6NO_3' + 2NO + 4H_2O;$$

$$\text{or, } Cu + 4H^{\cdot} + 2SO_4'' = Cu^{\cdot\cdot} + SO_4'' + SO_2 + 2H_2O.$$

Lead

Another apparent exception to the statements herein made is in the case where a water containing an excess of lime, and, therefore, no hydrion, has a decided solvent action on lead pipes, a condition which Fuller reports during the experimental work at Cincinnati. In this case also the lead probably goes into solution as part of an anion which, on concentration, would form a plumbate in the same way that aluminum with sodium hydroxide forms an aluminate.

$$Pb + Ca^{\cdot\cdot} + 2OH' = Ca^{\cdot\cdot} + PbO_2'' + H_2.$$

This of course is an artificial condition and one not often met with except in the case of softening or "lime and iron" plants.

Mr. Fuller does not explain the reaction nor does he state how the lead went into solution, but in all probability it was as an anion as stated, either PbO_2'' or $HPbO_2'$.

Role of Oxygen

Thus far in my discussion I have not alluded to the action of oxygen, which is generally considered the all-important factor in the action of water on pipes. Walker *et als.*, in their study on the Corrosion of Iron and Steel, concluded among other things that the primary function of oxygen in the corrosion of iron is in depolarizing those cathodic portions of the iron upon which the hydrogen tends to precipitate and that it acts only secondarily to oxidize ferrous to ferric iron. This means that in the absence of oxygen (an extremely unnatural condition) there would be a tendency to polarization in a quiet water which would act as a preventive to the further formation of hydrogen gas and a concomitant retardation to the solution of a metal. Without doubt the low degree of action which Clark found when lead was placed in distilled water with exclusion of air was due to the same cause.

Electrolysis

In the case of electrolysis of pipes the metal is dissolved in exactly the way described above, but the action is accelerated by the action of the electric current which tends to drive the metals into solution at the point or points where the current leaves the pipe to enter the water — whether inside the pipe or out. Investigations are under way to determine the extent of corrosion of pipes in moist soils so that we may know how much of the corrosion is natural (so to say) and how much induced by the action of stray currents from electric railways, etc.

Conditions affecting Solution of Metals

Other conditions which tend to increase or retard the action of water on pipes are temperature, pressure, concentration of salts, amount of organic matter, etc. Increase in any of these factors tends to increase the action of water on pipes except in such cases as where the salts in solution unite with the metals to form insoluble compounds which deposit on the pipes to form coatings through which the water cannot act. Such coatings form chiefly on lead and copper pipes and are very effectual in preventing the solution of the metal of the pipe.

Forms of Action

The explanations given above embrace practically all forms of action which water has upon pipes. This action is described under various names: corrosion or eating away; pitting, formation of

depressions; electrolysis, decomposition of a pipe by an electrical current; tuberculation, action accompanied by the formation of tubercules or limpets. All phenomena are due to one principal cause, — the solution of the metal. In all cases the metal replaces something in the water.

It matters not whether a pipe is laid through a stream (surrounded by water) or in moist soil; whether water passes through the pipe or outside of it. If the metal is exposed inside or out and the proper conditions prevail, action will result.

Aside from mechanical abrasion the method of action explains all natural and some artificial occurrences. The metal of the pipe, by virtue of its solution pressure, replaces the hydrogen ion occurring naturally in the water, and the hydrogen gas so formed escapes to the atmosphere if possible.

Remedial Measures

Now that we have taken so much time in arriving at an understanding of the action of water upon pipes, what does it all amount to? It amounts to this: that understanding what the elements concerned in the action are, and knowing what their properties are, we are so able to treat the water that their effect may be overcome. In one particular case I was the fifth chemist called in by a water company to determine their trouble. Every other one had pronounced the water of exceptional purity, but even then the water company were not able to make the consumers believe so. At the source the supply was of " exceptional purity," but the water had a powerful solvent action on iron pipes so that by the time it reached the consumers it not only contained large amounts of iron but had a very offensive odor and taste. An inexpensive method of removing the dissolving substance was found and the effect was so pronounced that the very next day after starting the apparatus every one in town remarked about the improved conditions and the water is now giving general satisfaction. Not one of the chemists preceding me had made a determination for even the presence of the element by virtue of which the water affected the pipes.

Knowing what the offending impurities in any water are, it is comparatively easy to know how they get there and so how to get them out. The case just cited was handled in the manner outlined above.

It is impossible to outline any method of procedure which will

furnish relief in all cases as no two are exactly alike, but in general it can be said that in most cases a simple aëration will accomplish remarkable results.

DISCUSSION.

THE PRESIDENT. This paper is now open for discussion.

MR. B. B. HODGMAN. Mr. President, I should like to ask Mr. Howe if it is the hydrogen ions that affect the iron.

MR. HOWE. The hydrogen ions, under proper conditions, are replaced by the iron metal of the pipe, in the case of an iron pipe.

MR. HODGMAN. Are the hydrogen ions found in waters which are very alkaline?

MR. HOWE. They occur in nearly all natural waters, even very alkaline waters.

MR. E. D. ELDREDGE. I would like to ask Mr. Howe if there is more rust on the pipes in summer — in high temperature — than in low temperature; if rust is present in greater quantities at one time of the year than another.

MR. HOWE. Usually in summer there is more carbon dioxide formed, the carbon dioxide being formed by the decomposition of vegetable matter, so that there is more of it to go into solution. But, on the other hand, the increased temperature will drive it from solution; just the same as when you boil water in a teakettle, or in any open vessel, the boiling process liberates all the carbon dioxide and with it the hydrogen ions which accompany it. That is the reason that boiled water is so much softer than water not boiled, — because the carbon dioxide and the accompanying hydrogen ion — or metal which has replaced it — is removed by the boiling process.

Briefly, in answer to your question, there is more carbon dioxide in summer to be dissolved, but the higher temperature will allow the solution of less. So the action in winter would be greater, because the decreased temperature allows more carbon dioxide, and the accompanying hydrogen ion, to go into solution, and so act upon the pipe.

MR. A. O. DOANE. I have noticed that hot water has a much more corrosive action upon pipes than cold water; hot water meters are very difficult to maintain. Now, I should like to ask

Mr. Howe to explain the more corrosive action of the hot water than the same water when it is cold.

MR. HOWE. Mr. President, it is almost impossible to discuss the subject upon general principles, because waters are so different; but in the presence of certain salts there would be a formation of hydrogen ions induced by heat which would not occur in other waters. That would be the case particularly in hard waters containing magnesia.

MR. DOANE. The particular case I had reference to was water in the Metropolitan District, which is not considered hard water, although I think almost all hot waters do affect the composition parts of meters more than cold waters.

MR. HOWE. Under heat the action of water is much greater than it is when water is cold. In a boiler the water is confined, so that these elements which affect the metals are not allowed to escape; and the action would be greater if the water were confined, as in a boiler, and also the pressure would increase the action.

MR. G. E. WINSLOW. Mr. President, there have been a great many cases of lead poisoning from the water going through lead pipes; in the city of Waltham the pipes connecting the services with the mains are perhaps 18 or 20 inches long; I had occasion to take out a great many of them in years gone by, and in all cases I found them of a bright color inside. I would like to know what is the nature of the action of the water on that lead which might cause lead poisoning.

MR. HOWE. In answer to the gentleman's question I will say that in waters which naturally contain one grain per gallon of substances determined as carbonates, there is usually formed a coating over the lead which prevents further action of the water upon the pipe. In the case of distilled water, Mr. Clark found, in his work, "The Action of Water upon Metals," that a very much larger amount of lead was dissolved by distilled water than by water which contained a small quantity of dissolved salts. And the reason for that is, as stated, that a portion of the salts combines with the lead to form an insoluble lead salt, which joins with the lead pipe and prevents further action by the water. The lead is protected to a considerable extent by the formation of this insoluble lead salt on the pipe.

MR. S. H. MCKENZIE. I should like to inquire if an ordinary soft surface water would contain more than that one grain per gallon of carbonate just spoken of.

MR. HOWE. Some waters, Mr. President, contain much less than one grain per gallon, or 17 parts per million, particularly in our granite regions of New England; but usually nearly all waters contain that much; there are exceptions, however.

MR. MCKENZIE. If the water contained less than one grain of carbonate per gallon, would it be detrimental to the consumer?

MR. HOWE. In general terms, yes, that water would have an action upon lead pipe.

MR. MCKENZIE. If, in removing the goose neck, you find a sort of slimy coating upon the inside, would you say that lead had been coated over?

MR. HOWE. This coating usually has considerable substance to it; the carbonate usually has more consistency. The slimy coating might be something else, or else it might be hydroxide. It would be impossible to tell without examination.

MR. E. B. PHELPS. Mr. President, there is one aspect of this question which Mr. Howe just alluded to; that is, the possibility of action where two metals are coupled up in the same pipe system. I have recently been in the middle West, where there is an alkaline water which, according to Mr. Howe's theories, ought not to have great solvent action, but this water has very serious solvent action upon galvanized iron pipe, and the trouble is traced to the very common use of brass pipe in the faucets.

THE PRESIDENT. Is there anything further to be said?

MR. FULLER. I should like to ask Mr. Howe for just a word with regard to the use of galvanized iron pipe for service pipes, or for use in houses, as to their desirability for conveying water.

MR. HOWE. It depends entirely upon the composition of the water.

MR. FULLER. Take a ground water, Mr. Howe, for instance.

MR. HOWE. Ground water affects all pipes, generally, more than surface water; of course it contains more of this active element. In other ways it would affect the pipes less, on account of the presence of more salts which would exist to form protective coatings. An exact knowledge of a definite place must be had in order to pass definite judgment.

PROCEEDINGS.

Annual Meeting.

Hotel Brunswick,
Boston, January 8, 1908.

The President, Mr. John C. Whitney, in the chair.
The following members and guests were present:

Honorary Member.

F. W. Shepperd. — 1.

Members.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, H. K. Barrows, G. W. Batchelder, J. E. Beals, A. F. Ballou, J. W. Blackmer, George Bowers, Dexter Brackett, E. C. Brooks, James Burnie, George Cassell, J. C. Chase, C. E. Childs, H. W. Clark, F. L. Clapp, R. C. P. Coggeshall, M. F. Collins, J. W. Crawford, J. H. Child, A. W. Cuddeback, L. E. Daboll, A. O. Doane, E. D. Eldredge, I. T. Farnham, J. H. Flynn, F. F. Forbes, W. E. Foss, A. N. French, F. L. Fuller, H. M. Geer, J. A. Gould, F. J. Gifford, R. A. Hale, F. E. Hall, T. G. Hazard, Jr., D. A. Heffernan, B. B. Hodgman, H. G. Holden, Freeland Howe, Jr., C. L. Howes, W. S. Johnson, J. W. Kay, Willard Kent, F. C. Kimball, G. A. King, E. S. Larned, S. H. McKenzie, Thomas McKenzie, N. A. McMillen, A. E. Martin, John Mayo, J. F. Moore, C. A. Mixer, O. E. Parks, W. W. Patch, H. E. Royce, H. W. Sanderson, P. R. Sanders, E. M. Shedd, C. W. Sherman, J. Waldo Smith, G. H. Snell, G. A. Stacy, G. T. Staples, J. T. Stevens, W. M. Stone, W. F. Sullivan, H. L. Thomas, R. J. Thomas, W. H. Thomas, D. N. Tower, C. A. Townsend, W. H. Vaughn, J. C. Whitney, L. J. Wilber, F. B. Wilkins, H. B. Wood. — 79.

Associates.

Anderson Coupling Company, by Charles E. Pratt and F. A. Leavitt; Harold L. Bond & Co., by Harold L. Bond; Builders Iron Foundry, by A. B. Coulters; Chapman Valve Manufacturing Company, by Edward F. Hughes; The Fairbanks Company, by George H. Gray; Hersey Manufacturing Company, by Walter A. Hersey; International Steam Pump Company, by Samuel Harrison; Lead Lined Iron Pipe Company, by T. E. Dwyer; Ludlow Valve

Manufacturing Company by, H. F. Gould; National Meter Company, by C. H. Baldwin, J. G. Lufkin, and H. L. Weston; National Water Main Cleaning Company, by B. B. Hodgman; Neptune Meter Company, by Fred A. Smith and H. H. Kinsey; Norwood Engineering Company, by H. W. Hosford; Platts Iron Works Company, by F. H. Hayes; Rensselaer Manufacturing Company, by C. L. Brown and F. S. Bates; A. P. Smith Manufacturing Company, by F. N. Whitcomb; Thomson Meter Company, by E. M. Shedd; Chas. Millar & Son Company, by Charles F. Glavin; Union Water Meter Company, by F. E. Hall; Water Works Equipment Company, by W. H. Van Winkle; R. D. Wood & Co., by W. F. Woodburn, Harry Crowther, and H. A. Jensennius. — 28.

GUESTS.

James G. Hill, water commissioner, Dr. T. T. Carroll, Lowell, Mass.; L. R. Washburn and William E. Smith, members Water Board, New Bedford, Mass.; A. E. Blackmer, superintendent water works, Plymouth, Mass.; Joseph Weeks, Bridgewater, Mass.; Horace Mitchell, Kittery Point, Me.; J. J. Ryan, foreman water works, Southington, Conn.; D. W. McCormo, Panama; Mr. A. C. Horn, New York City; L. H. Camfel and Charles R. Gow, Boston, Mass. — 12.

At the close of the dinner the meeting was called to order by President Whitney, who said:

PRESIDENT'S ADDRESS.

Gentlemen of the New England Water Works Association, — Again we meet to review briefly the work of the year just passed, the twenty-fifth in the history of our Association.

Since the last report we have to record the death of six members:

Lewis P. Collins, ex-mayor of Lawrence, Mass., elected a member December 12, 1894.

Myron Edward Evans, C. E., New York City, president of the Cape Breton Railway, elected a member June 13, 1900.

Valentine C. Hastings, superintendent of the Concord, N. H., water works, a member since June 10, 1886.

Arthur J. L. Loretz, M. E., New York City, elected to membership December 9, 1896.

James W. Locke, general foreman water works, Brockton, Mass., a member since January 9, 1895.

John F. J. Mulhall, Boston, Mass., water-works accountant and treasurer of several water companies, elected to membership November 14, 1900.

Mr. Hastings had served on various committees, had twice been vice-president, took an active interest in the Association, and his loss was deeply felt. He had been superintendent at Concord, N. H., for thirty-four years.

Our total membership is now 702, a gain for the year of 18. It should, perhaps, be emphasized that this membership is absolutely net, all whose assessments were overdue having been dropped from the rolls.

The rate of growth seems fairly satisfactory until we attempt to analyze our membership, when we discover that over 40 per cent. of New England municipalities having a population in excess of 3 000 are not represented in this Association.

These figures open before our vision a broad, fruitful field for missionary work; we know that membership in our Association would benefit every one of these outsiders; we believe that each one would bring something of value to our meetings.

The first president of our Association in his address recommended that each city and town assume the expense incurred in attending these meetings, as the knowledge obtained was of direct benefit to the municipality, and it may further be said that the water-works official who is neither a member of this Association nor a subscriber to the JOURNAL is handicapped in the administration of his plant.

We are to be congratulated on our financial condition. After paying all bills there is a treasury balance of over $4 000, a substantial increase over 1906, and more than double the amount possessed by the Association six years ago.

The JOURNAL, of which we all are proud, speaks for the intelligent, discriminating work of the Editor. Particular mention should be made of the water-works statistics printed in the September number. It is but a simple statement of fact to say that this invaluable publication is still improving.

Mr. Sherman has also brought up to date a table appearing first in 1902, and which at this time is of special interest as showing, with other information, the progress of the Association during the twenty-five years of its existence.

Year.	President.	Membership at End of Year.				Annual Convention..		Receipts.	Expenditures.	Cash Balance.
		Members.	Associate.	Honorary.	Total.	Place.	Date.			
1882	(Organized)	27	—	—	27	Boston, Mass.	June 21, '82			
1882–3	*James W. Lyon	37	6	—	43	Worcester, Mass.	June 21, '83	$245.00	$87.86	$157.14
1883–4	Frank E. Hall	48	9	—	57	Lowell, Mass.	June 19–20, '84	156.14	171.90	141.38
1884–5	*George A. Ellis	83	44	—	127	Springfield, Mass.	June 18–19, '85	651.84	511.44	281.78
1885–6	R. C. P. Coggeshall	106	47	—	153	New Bedford, Mass.	June 16–18, '86	1 658.50	1 643.42	296.86
1886–7	*Henry W. Rogers	137	52	2	191	Manchester, N. H.	June 15–17, '87	1 342.28	1 066.98	572.16
1887–8	*Edwin Darling	181	54	3	238	Providence, R. I.	June 13–15, '88	2 013.30	1 697.15	888.31
1888–9	*Hiram Nevons	209	64	4	277	Fall River, Mass.	June 12–14, '89	2 204.07	2 127.70	964.68
1889–90	Dexter Brackett	257	73	5	335	Portland, Me.	June 11–13, '90	2 511.27	2 346.65	1 129.30
1890–1	*Albert F. Noyes	281	74	5	360	Hartford, Conn.	June 10–12, '91	3 055.13	1 884.78	2 299.65
1891–2	Horace G. Holden	290	70	5	365	Holyoke, Mass.	June 8–10, '92	2 887.17	3 278.54	1 908.28
1892–3	George F. Chace	338	69	5	412	Worcester, Mass.	June 14–16, '93	3 422.61	3 317.22	2 013.67
1893–4	*Geo. E. Batchelder	365	73	5	443	Boston, Mass.	June 14–16, '94	3 208.85	3 259.07	1 963.45
1894–5	George A. Stacy	401	81	5	487	Burlington, Vt.	Sept. 11–13, '95	3 147.41	3 115.99	2 673.03
1895–6	Desmond FitzGerald	442	82	5	529	Lynn, Mass.	June 10–12, '96	3 179.91	3 148.49	2 704.45
1896–7	*John C. Haskell	464	80	5	549	Newport, R. I.	Sept. 8–10, '97	3 340.23	3 322.94	2 721.74
1897–8	Willard Kent	488	77	5	570	Portsmouth, N. H.	Sept. 14–16, '98	3 002.13	2 786.95	2 936.92
1898–9	Fayette F. Forbes	494	73	5	572	Syracuse, N. Y.	Sept. 13–15, '99	2 825.71	3 050.23	2 712.40
1899–1900	Byron I. Cook	519	70	5	594	Rutland, Vt.	Sept. 19–20, '00	4 920.49	5 524.65	2 108.24
1901	Frank H. Crandall	493	58	4	555	Portland, Me.	Sept. 18–20, '01	4 238.55	4 283.22	2 063.57
1902	Frank E. Merrill	522	60	5	587	Boston, Mass.	Sept. 10–12, '02	5 158.48	4 680.32	2 541.73
1903	Charles K. Walker	520	55	3	586	Montreal, Canada	Sept. 9–11, '03	5 032.40	4 505.08	3 069.05
1904	Edwin C. Brooks	538	58	8	604	Holyoke, Mass.	Sept. 14–16, '04	5 328.31	5 528.21	2 869.15
1905	George Bowers	584	53	8	645	New York, N. Y.	Sept. 13–16, '05	5 431.16	5 411.58	2 888.73
1906	Wm. T. Sedgwick	618	51	15	684	White Mts., N. H.	Sept. 12–14, '06	5 366.94	4 845.14	3 410.53
1907	John C. Whitney	636	51	15	702	Springfield, Mass.	Sept. 11–13, '07	5 291.83	†4 222.06	4 480.30

* Deceased. † Not including December JOURNAL and reprints.

The usual winter meetings have been held and were well attended; papers proved interesting and were thoroughly discussed.

Special mention should be made of the paper by Mr. William S. Johnson given at the March meeting, "Some New Facts Relating to the Effect of Meters on the Consumption of Water." His view of the subject was from a somewhat unusual standpoint and brought out so full a discussion that the paper, with accompanying comments, filled the June number of the JOURNAL.

In June we had a trip to Gloucester, going by steamer and returning by train, with a shore dinner in Gloucester and a trolley trip "around the Cape."

The annual convention at Springfield in September was a success in every way. Attendance was large, papers interesting, hotel accommodations satisfactory, a well-managed exhibition of water-works appliances, and on the last day a visit to the Springfield filtration plant at Ludlow, and, through the courtesy of the Chapman Valve Manufacturing Company, an opportunity to inspect their works and to partake of luncheon which they kindly provided.

At Springfield, largely due to papers read on "Water Rights" and "Value of Water Powers," with the discussion which followed, it was

Voted: "That a committee of five be appointed by the President to collect data relating to awards that have been made for damages resulting from the diversion of water; also to consider the practicability of joint action with the National Cotton Manufacturers' Association or other organization of mill owners, leading to the formulating of standard rules and methods of computing or assessing damages for the diversion of water."

At the November meeting a committee of five was appointed to compile information relating to awards that have been made in water-works valuation cases.

At the same session a committee of five was appointed to prepare a standard specification for fire hydrants.

Three able committees have been appointed to consider these important subjects, and their findings, when presented, will prove of the greatest value.

Reports of the Secretary, Treasurer, Editor, and Auditing Com-

mittee will show in detail the standing of the Association as compared with that of a year ago.

We appreciate fully the good work of these officers, not forgetting the painstaking service of the Assistant Secretary.

I thank you for your support and consideration the past year, and let us bear in mind that the New England Water Works Association can move onward and upward only by the hearty coöperation of every member.

Report of Secretary.

Mr. President and Members of the New England Water Works Association, — I have the honor to submit the following report of membership, receipts and disbursements of the New England Water Works Association for the year ending December 31, 1907:

Membership.

The total membership of the Association of all grades Dec. 31, 1906, was	684
" " " " " " " " " " 1907, "	702
A net increase during the year of	18

The increase being in the grade of member, the list of honorary members remaining the same as last year, and the changes in the associate grade resulting in the present number of associates being the same as on December 31, 1906.

The present membership is divided among the different grades as follows:

Members	636
Honorary members	15
Associates	51
A total of	702

The detail of changes in membership is as follows:

Membership.

The total membership of the Association January 1, 1907, was	618
The present membership is	636
A net increase during the year of	18

Members.

January 1, 1907.	Total members		618	
	Withdrawals:			
	Resigned	13		
	Died	6		
	Dropped	32	51	567

	Initiations:			
	January	4		
	February	5		
	March	10		
	September	19		
	November	5		
	December	4	47	
	Seven members elected in 1906 but qualified in 1907		7	54
	Reinstated:			
	Members dropped in 1906		6	
	Members dropped in 1907		9	15 636

HONORARY MEMBERS.

January 1, 1907.	Honorary members	15	
January 1, 1908.	Honorary members		15

ASSOCIATES.

January 1, 1907.	Total associates		51	
	Withdrawals:			
	Resigned	2		
	Died	1	3	
			48	
	Initiations:			
	September	2		
	December	1	3	51
January 1, 1908.	Total membership			702

SUMMARY OF RECEIPTS AND DISBURSEMENTS OF THE NEW ENGLAND WATER WORKS ASSOCIATION FOR THE YEAR 1907.

RECEIPTS.

Initiation Fees			$256.00
Annual Dues:			
Members	$1 881.00		
Associates	750.00	$2 631.00	
Fractional dues:			
Members	$29.00		
Associates	15.00	44.00	
Past dues		29.35	
Total dues			2 704.35

Advertisements	$1 728.75
Subscriptions	167.75
JOURNALS sold	256.17
Sundries	42.30
Excess of receipts over expenditures June 26, 1907(June Excursion)	23.78
Total receipts	$5 179.10

DISBURSEMENTS.

JOURNAL	$1 137.47
Assistant Secretary	600.00
Stationery and printing	400.49
Rent	400.00
Advertising Agent	306.00
Editor	300.00
Secretary	200.00
Stenographer	195.25
Incidental expenses	184.20
Membership list	150.50
Reprints	101.50
Music	80.00
Stereopticon	70.40
Treasurer	50.00
Badges	45.50
Insurance	15.00
Library	5.50
Total disbursements	$4 241.81*
Receipts in excess of expenditures	$937.29
At present there is due the Association:	
For advertisements	$280.00
For initation fee and dues	14.00
For JOURNALS	5.00
For subscriptions	3.00
For Standard Specifications	.80
Total	$302.80

I know of no outstanding bills against the Association except those for the December issue of the JOURNAL not yet received.

Respectfully submitted,

WILLARD KENT, *Secretary.*

On motion duly seconded the report of the Secretary was accepted and placed on file.

* Note that this differs slightly from the Treasurer's statement since it includes two small bills which have been lost in the mails and are not yet paid.

REPORT OF TREASURER.

LEWIS M. BANCROFT, TREASURER,

In account with the New England Water Works Association.

RECEIPTS.			EXPENDITURES.		
1907.					
Jan. 5	Balance on hand	$3 410.53	Paid bills, as per itemized statement		$4 222.06
Aug. 1	Dividends, Peoples Savings Bank, Worcester	62.98	BALANCE ON HAND.		
Dec. 7	Dividends, Mechanics Savings Bank, Reading	49.75	Deposit Peoples Savings Bank, Worcester	$1 600.00	
Feb. 4	Rec'd of Willard Kent, Sec'y,	$1 427.90	Deposit Mechanics Savings Bank, Reading	1 202.95	
March 6	,, ,, ,, ,,	692.95	Deposit First National Bank, Reading	1 273.20	
May 8	,, ,, ,, ,,	656.45	Deposit Liberty Trust Company, Boston	404.15	
July 10	,, ,, ,, ,,	651.20			4 480.30
July 23	,, ,, ,, ,,	160.28			
Oct. 23	,, ,, ,, ,,	775.20			
Dec. 6	,, ,, ,, ,,	404.15			
1908.					
Jan. 3	,, ,, ,, ,,	410.97			
		5 179.10			
		$8 702.36			$8 702.36

READING, MASS., January 6, 1908.

LEWIS M. BANCROFT, *Treasurer.*

DETAILED STATEMENT OF BILLS PAID.

1907.		
January 15	Emerson H. Packard, music, January 9	$10.00
	Hub Engraving Company, plates	7.61
19	L. M. Bancroft & Son, treasurer's bond	15.00
February 7	Miss J. M. Ham, salary for January	45.00
15	D. Gillies' Sons, printing	66.02
March 8	Arthur D. Marble, auditor	3.00
	Harvard Quartet, music, February 13, 1907	25.00
	Hub Engraving Company, plates	2.81
	Miss J. M. Ham, salary to March 1	55.00
	D. Gillies' Sons, circulars	4.50
14	B. D. B. Bourne, stereopticon	10.00
	Boston Society of Civil Engineers, rent to February 28	100.00
21	Daggett's Orchestra, music, March 13	15.00
	Thomas P. Taylor, stereopticon	10.00
	Miss J. M. Ham, salary to April 1	50.00
	Charles W. Sherman, salary to March 31	75.00
	Charles W. Sherman, postage and express	8.00
April 15	Samuel Usher, printing	8.00
	Hub Engraving Company, plates	16.78
	W. H. Hughes, binding JOURNAL and index	5.50
	Bacon & Burpee, reporting January, February, and March meetings	70.00
	Robert J. Thomas, advertising agent, to April 1	82.75
17	Samuel Usher, March JOURNAL and reprints	360.50
	Willard Kent, salary as Secretary to March 31	50.00
	Willard Kent, sundry expenses	52.30
May 2	Samuel Usher, printing advance proofs	7.50
	Miss J. M. Ham, salary to May 1	50.00
8	Miss J. M. Ham, sundry expenses	39.72
	W. N. Hughes, envelopes	48.60
June 5	Miss J. M. Ham, salary to June 1	50.00
	Samuel Usher, lists of members	150.50
	W. N. Hughes, envelopes	24.00
19	Hub Engraving Company, plates	9.90
	John C. Chase, floral wreath for funeral of V. C. Hastings	10.00
	Miss J. M. Ham, salary for June	50.00
	Charles W. Sherman, salary to July 1	75.00
	Charles W. Sherman, postage and express	6.50
July 26	Miss J. M. Ham, salary for July	50.00
	Miss J. M. Ham, sundry expenses	39.79
	Amount carried forward	$1,759.28

	Amount brought forward	$1,759.28
July 26	Boston Society of Civil Engineers, rent to May 31,	100.00
	Willard Kent, salary to July 1	50.00
	Willard Kent, telephones	18.70
August 9	Samuel Usher, circulars	2.00
	R. J. Thomas, advertising agent	77.25
20	Samuel Usher, June JOURNAL	264.65
September 5	W. N. Hughes, envelopes and printing	62.00
	Miss J. M. Ham, salary for August	50.00
26	Charles W. Sherman, salary to October 1	75.00
	Charles W. Sherman, postage and expenses . . .	7.00
	Whitehead & Hoag Company, badges	45.50
	Thomas P. Taylor, stereopticon	30.40
	The American Society of Mechanical Engineers, electrotypes	48.50
	Mary A. Powell, reporting twenty-sixth annual convention	66.00
October 23	Miss J. M. Ham, salary for September	50.00
	Miss J. M. Ham, sundry expenses	70.45
	Boston Society of Civil Engineers, rent to August 31,	100.00
	Willard Kent, salary to October 1	50.00
	Willard Kent, sundry expenses	19.80
November 7	Miss J. M. Ham, salary for October	50.00
	Springfield Photo-Engraving Company, plates . .	19.32
	Hub Engraving Company, plates	6.77
19	W. N. Hughes, printing	13.50
	Samuel Usher, advance copies	28.00
	Hub Engraving Company, plates	12.36
December 13	Miss J. M. Ham, salary for November	50.00
	R. J. Thomas, advertising agent	74.00
	William E. Whittaker, drafting	2.50
	Hub Engraving Company, plates	19.90
	Thomas P. Taylor, stereopticon	10.00
20	Boston Society of Civil Engineers, rent to November 30	100.00
1908.		
January 3	R. J. Thomas, advertising agent	72.00
	Miss J. M. Ham, salary for December	50.00
	Miss J. M. Ham, sundry expenses	20.81
	Samuel Usher, September JOURNAL and reprints .	427.64
	Hub Engraving Company, plates	4.23
	Charles W. Sherman, salary to December 31 . . .	75.00
	Charles W. Sherman, postage, etc.	8.00
	Willard Kent, salary to December 31	50.00
	Amount carried forward, ...	$4,040.56

	Amount brought forward	$4,040.56
January 3	Willard Kent, sundry expenses	47.25
	Lewis M. Bancroft, treasurer's salary to December 31	50.00
	Bacon & Burpee, reporting November and December meetings	59.25
	Thomas P. Taylor, stereopticon	10.00
	The Brunswick, music, December meeting	15.00
		$4 222.06

Report of the Editor.

Boston, January 8, 1908.

To the New England Water Works Association: — I present the following report for the Journal of the New England Water Works Association for the year 1907.

The accompanying tabulated statements show in detail the amount of material in the Journal; the receipts and expenditures on account of the Journal for the past year, including the cost of the December Journal and reprints, bills for which were received too late to pay in 1907, and which are, consequently, not included in the Secretary's and Treasurer's statements; and a comparison with the conditions of the seven preceding years.

Size of Volume. — The volume is somewhat larger than for the preceding year, and larger than any preceding annual volume, with one exception.

Illustrations. — The total cost of illustrations for the year has been $228.68, or 8.7 per cent. of the gross cost of the volume.

Reprints. — The usual fifty reprints of papers have been furnished to authors without charge. Some few reprints have also been furnished to members who have contributed discussions, themselves almost in the nature of papers. The net cost to the Association for reprints and advance copies has been $133 (assuming that the December reprints chargeable to members are promptly paid for), amounting to $7.40 for each of the eighteen papers published during the year.

Circulation. — The present circulation of the Journal is:

Members, all grades	702
Subscribers	59
Exchanges	24
Total	785

an increase of 18 over the preceding year.

Advertisements. — The December issue contained 28¼ pages of paid advertising, which, if maintained throughout the year, would mean an annual income

from this source of $1 940. A year ago the figures were 26.08 pages and $1 740, showing considerable increase during the year.

Pipe Specifications. — During the year the specifications for cast-iron pipe to the value of $30.70 have been sold. There has been no corresponding expense, so this represents a net gain. The net gain up to a year ago had been $109.05, so that the total net gain from this source to date is $139.75. There is still a fair stock of specifications on hand, probably about $25.00 worth if sold at retail.

The last two issues of the year have been very much delayed in their publication, and the December issue has gone to subscribers only this week, consequently bills for printing it and for reprints could not be paid in time to be included in the 1907 bills as listed by the Secretary and Treasurer. They have, however, been included in this report, and they amount to $565.20. I know of no other outstanding bills against the Association on account of the JOURNAL.

Respectfully submitted,

CHARLES W. SHERMAN, *Editor.*

TABLE No. 1.

STATEMENT OF MATERIAL IN VOLUME XXI, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1907.

Number.	Date.	Pages of Papers.	Proceedings.	Total Text.	Index.	Advts.	Cover and Contents.	Inset Plates.	Total.	Cuts.
1	March	73	35	108	–	31	4	2	145	5
2	June	73	9	82	–	32	4	2	120	16
3	September	117	17	134	–	31	4	3	172	16
4	December	166	10	176	8	31	4	13	232	60
	Total	429	71	500	8	125	16	20	669	97

TABLE No. 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXI, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1907.

RECEIPTS.		EXPENDITURES.	
From advertisements	$1 728.75	For printing JOURNAL	$1 508.99*
From sale of JOURNALS	256.17	For preparing illustrations	150.68
From sale of reprints	7.60	For editor's salary	300.00
Subscriptions	167.75	For editor's incidentals,	38.00
	$2,160.27	For advertising agent's commissions	306.00
		For reporting	195.25†
Net cost of JOURNAL	483.15	For reprints and advance copies	144.50
	$2 643.42	Gross cost of JOURNAL	$2 643.42

* Including $522.20 for December JOURNAL (not yet paid).
† Including $43.00 for December reprints (not yet paid).

TABLE No. 3.

COMPARISON BETWEEN VOLUMES XIV TO XXI, INCLUSIVE, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	Vol. XIV. 1899-1900.	4 Numbers of Vol. XV. 1900-1901.	Vol. XVI. 1902.	Vol. XVII. 1903.	Vol. XVIII. 1904.	Vol. XIX. 1905.	Vol. XX. 1906.	Vol. XXI. 1907.
Average edition (copies printed),	1 100	1 200	1 200	1 200	900	900	900	1 085
Average membership	583	586	571	587	596	625	665	693
Circulation at end of year	640*	617*	648*	656*	667	705	767	785
Pages of text	345	363	403	430	491	587	495	500
Pages of text per 1 000 members,	600	618	707	733	824	939	745	722
Total pages, all kinds	485	536	584	619	794*	784	662	669
Total pages per 1 000 members	832	913	1 020	1 051	1 332	1 254	995	964
GROSS COST:								
Total	$1 954.15	$2 194.26	$2 439.99	$2 706.05	$2 928.77	$3 266.65	$2 573.61	$2 643.42
Per page	4.03	4.10	4.18	4.38	3.69	4.17	3.88	3.95
Per member	3.35	3.75	4.27	4.61	4.91	5.23	3.87	3.82
Per member per 1 000 pages	6.91	6.99	7.32	7.46	6.18	6.67	5.85	5.70
Per member per 1 000 pp. text	9.71	10.13	10.60	10.72	10.00	8.91	7.81	7.62
NET COST:								
Total	$347.55	$332.90	$622.89	$770.62	$648.11	$1 072.95	$387.96	$483.15
Per page	.72	.62	1.07	1.25	.82	1.37	.58	.72
Per member	.60	.57	1.09	1.31	1.09	1.72	.58	.70
Per member per 1 000 pages	1.23	1.06	1.87	2.12	1.30	2.20	.88	1.04
Per member per 1 000 pp. text,	1.73	1.57	2.71	3.05	2.22	2.93	1.18	1.39

* Exclusive of three hundred sample copies.

On motion duly seconded the Editor's report was accepted as read and placed on file.

THE PRESIDENT. The next thing on the program is the report of the Finance Committee. My impression is that the chairman of that committee is ill, and I think Mr. Cassell is the ranking member.

MR. CASSELL. Mr. President, owing to the absence of the two senior members of the Finance Committee — I mean in point of service only — I find that I, the infant member of the committee, have been called upon to read the report of the Finance Committee.

REPORT OF FINANCE COMMITTEE.

BOSTON, MASS., January 6, 1908.

In compliance with Section 5 of Article 6 of the Constitution of the New England Water Works Association, the Finance Committee, with the exception of Mr. Arthur D. Marble, who could not attend on account of illness, met this day at the headquarters of the Association and attended to their duties in auditing the accounts of the Treasurer and Secretary.

We examined the Secretary's books, verified the accounts, and found the total receipts, $5 179.10, as stated, to be correct, which amount he has turned over to the Treasurer, as his vouchers testify.

We examined the Treasurer's accounts and found that his receipts from the Secretary agree with the amount as stated above. We also examined the record of his payments and find them correctly recorded and properly certified and vouched for.

The disbursements amount to $4 222.06.

We find the invested fund in two savings banks, with interest to date, namely, $62.98 and $49.75, amounts to $2 802.95, and cash on hand to be $1 677.35, all as stated in the Treasurer's report, making a total of $4 480.30 as a balance on hand for the beginning of the year.

Your committee desires to commend the work of the Treasurer, Secretary, and Assistant Secretary for the clear and concise manner in which the books and finances of the Association are kept, and to acknowledge the courtesies extended by them.

Respectfully submitted,

WILLIAM E. MAYBURY.
GEORGE CASSELL.

On motion duly seconded the report of the Finance Committee was accepted and placed on file.

THE PRESIDENT. It seems proper at this time to take up the matter of the acceptance or rejection of the Treasurer's report, it having been passed on and certified as being correct.

On motion duly seconded the report of the Treasurer was accepted and placed on file.

PIPE SPECIFICATIONS.

THE PRESIDENT. The chairman of the Committee on Standard Specifications for Cast-Iron Pipe is present and desires to make a few remarks.

MR. DEXTER BRACKETT. The committee has no formal report to make, but as I have had during the past year some correspondence with the chairman of a committee of the American Water Works Association having this question under consideration, I think it may interest the members of this Association to know what is being done in the matter of standard water-pipe specifications by the American Water Works Association, as it may affect the action of this Association.

At the annual convention of the American Water Works Association held at Toronto in June, 1907, a committee of that association reported a form of standard specifications for cast-iron water pipe which follows very closely the wording and the tables giving standard dimensions and weights that have been adopted by this Association. They have, however, suggested some changes, the principal one being a reduction in the number of standard classes; and they have added a further set of tables giving standard thicknesses and weights for heavier pipes. The standards of the New England Water Works Association have 10 classes adapted for heads from 50 feet to 500 feet inclusive, while they have presented 8 standards adapted for heads from 100 feet to 800 feet.

They have not as yet got their specification in a form which your committee is willing to recommend for your approval. The differences are slight, but some of the changes proposed are not, in our opinion, any advance over the specifications which we have adopted.

It will certainly be much better if a standard which will be used by the entire country can be agreed upon, and we hope that this

may be accomplished and that the matter may be brought to your attention later, but your committee does not believe in the adoption of another specification which would be but little, if any, better than the one which has been already used for several years. The fact that your Secretary has sold during the past year about three hundred copies of the standard specifications, in addition to what have been quite generally distributed throughout the country in past years, shows that it is being used.

THE PRESIDENT. The next item on the program is the report of the tellers appointed to canvass ballots. We would like to hear from Mr. Arthur F. Ballou.

ELECTION OF OFFICERS.

MR. BALLOU. Your tellers have carefully counted the ballots and examined them, and present the following results:

REPORT OF TELLERS OF ELECTION.

Whole number votes cast	213
Not properly endorsed	9
For President.	
ALFRED E. MARTIN	199
For Vice-Presidents.	
M. N. BAKER	200
GEORGE A. KING	200
MICHAEL F. COLLINS	200
GEORGE F. WEST	200
WILLIAM F. SULLIVAN	199
ROBERT A. CAIRNS	201
For Secretary.	
WILLARD KENT	202
For Treasurer.	
LEWIS M. BANCROFT	200
For Editor.	
CHARLES W. SHERMAN	200
For Advertising Agent.	
ROBERT J. THOMAS	201
For Additional Members of Executive Committee.	
GEORGE W. BATCHELDER	200
D. N. TOWER	200
GEORGE A. STACY	201
For Finance Committee.	
GEORGE CASSELL	200
JOHN C. CHASE	200
WILLIAM E. MAYBURY	201

ARTHUR F. BALLOU.
S. A. AGNEW.

THE PRESIDENT. The result of this election seems to be practically unanimous. I think we would all like to hear something from our newly elected president, Mr. Martin, who has been a member of our Association for twenty-two years, and is known and respected by the whole Association. [Applause.]

MR. ALFRED E. MARTIN. *Gentlemen of the New England Water Works Association,* — I have no doubt Mr. Whitney is just as pleased to hear from me at this time as we were to hear from him a year ago.

I thank you sincerely from the bottom of my heart for giving me the privilege and honor of presiding over our Association, a privilege and honor which in the wildest flights of my imagination I never hoped would be mine. [Laughter.] It is true I have been a member twenty-two years; I was elected at the memorable meeting — I think it was memorable, at least judging by reports; I wasn't present at the time — when the two associations, the American and ours, met together in Boston in 1885.

I assure you, gentlemen, that I appreciate this honor, and that my appreciation is just as great as though I could express it in language that would be more pleasing to you and more satisfactory to me. But I am no orator, and consequently you will have to accept the simple statement of the fact itself. If there are any of you present who have ever seen me in similar positions, you may know that I am a better worker than I am talker. I therefore will not take up more of your time, which is too valuable to be wasted. I thank you, gentlemen, once more. [Applause.]

THE PRESIDENT. We all know that Mr. Martin is a worker, and it seems to us that he is also a very fair talker.

The Secretary has a few applications for membership, which we will put in at this time.

The Secretary read the names of the following four applicants who, having been recommended by the Executive Committee, were elected to membership:

William Atkins McKenzie, Meriden, Conn, engineer connected with the Carnegie Lake, Princeton, N. J.; Milton W. Davenport, New Britain, Conn., chemist in charge of sewage filtration plant; Walter E. Spear, Babylon, N. Y., division engineer, Board of Water

Supply; George W. Cutting, Jr., Weston, Mass., in independent engineering practice.

Mr. Harry L. Thomas, assistant superintendent of water company, Hingham, Mass., read a paper entitled "Experience with a Producer Gas Plant." It was discussed by Messrs. E. H. Gowing, Crowthers, S. H. McKenzie, F. L. Fuller, A. O. Doane, I. T. Farnham, George Cassell, and F. A. Barbour.

Mr. F. F. Forbes, superintendent of water works, Brookline, Mass., read a paper entitled "One Year's Practical Everyday Experience with an Automobile for Business, by a Water-Works Man." It was discussed by Messrs. Dexter Brackett, W. F. Sullivan, Coulters, and J. H. Flynn.

Mr. Freeland Howe, Jr., read a paper entitled "Action of Water on Water Pipes." It was discussed by Messrs. B. B. Hodgman, E. D. Eldredge, A. O. Doane, G. E. Winslow, S. H. McKenzie, E. B. Phelps, and F. L. Fuller.

The meeting then adjourned.

February Meeting.

Hotel Brunswick, Boston, Mass.,
February 12, 1908.

A regular meeting of the Association was held at the Hotel Brunswick, Boston, Mass., on Wednesday, February 12, 1908, at 2 P.M. President Alfred E. Martin occupied the chair, and the following were present:

Members.

S. A. Agnew, J. M. Anderson, M. N. Baker, C. H. Baldwin, L. M. Bancroft, G. W. Batchelder, J. F. Bigelow, C. A. Bogardus, George Bowers, Dexter Brackett, E. C. Brooks, G. A. P. Bucknam, George Cassell, J. C. Chase, C. E. Childs, H. W. Clark, J. H. Child, R. C. P. Coggeshall, M. F. Collins, W. R. Conard, J. W. Crawford, F. W. Dean, A. O. Doane, John Doyle, E. D. Eldredge, J. N. Ferguson, W. E. Foss, S. DeM. Gage, F. J. Gifford, A. S. Glover, F. E. Hall, L. M. Hastings, T. G. Hazard, Jr., H. G. Holden, J. L. Howard, W. S. Johnson, E. W. Kent, Willard Kent, Patrick Kieran, G. A. King, L. P. Kinnicutt, Morris Knowles, N. A. McMillen, D. E. Makepeace, A. D. Marble, A. E. Martin, W. E. Maybury, F. E. Merrill, Leonard Metcalf, H. A. Miller, William Naylor, R. R. Newman, O. E. Parks, E. M. Peck, J. H. Perkins, W. H. Richards, A. L. Sawyer, E. M. Shedd, C. W. Sherman, G. H. Snell, G. A. Stacy, W. F. Sullivan, C. N. Taylor, H. L. Thomas, R. J. Thomas, W. H. Thomas, J. A. Tilden, D. N. Tower, W. H. Vaughn, R. S. Weston, J. C. Whitney, G. E. Wilde, C.-E. A. Winslow, and G. E. Winslow. — 74.

Associates.

The Anderson Coupling Company, by F. A. Leavitt; Harold L. Bond Company, by Harold L. Bond; Builders' Iron Foundry, by F. N. Connet; Eagle Oil and Supply Company, by John L. Hamilton; Hersey Manufacturing Company, by Albert S. Glover, J. A. Tilden, and W. A. Hersey; International Steam Pump Company, by Samuel Harrison; Ludlow Valve Manufacturing Company, by H. F. Gould; H. Mueller Manufacturing Company, by George A. Caldwell; National Meter Company, by C. H. Baldwin, J. G. Lufkin, and H. L. Weston; Neptune Meter Company, by H. H. Kinsey; Perrin, Seamans & Co., by Chas. E. Godfrey; Platt Iron Works Company, by F. H. Hayes; Rensselaer Manufacturing Company, by C. L. Brown; A. P. Smith Manufacturing Company, by Fred N. Whitcomb; Thomson Meter Company, by E. M. Shedd; Union Water Meter Company, by E. M. Barnard, F. E. Hall, and Charles F. Merrill. — 22.

GUESTS.

F. L. Weaver, Harry Girard, A. H. Weaver, Lowell, Mass.; Frank H. Gunther, Dracut, Mass.; Henry W. Littlefield, of Allen & Reed, Inc., Providence, R. I.; George F. Merrill, Supt., Greenfield, Mass.; Hon. S. O. Bigney, Attleboro, Mass.; A. Fleming, Wm. J. Carroll, Joseph H. White, J. Rodney Ball, Dr. J. T. Collins, Lawrence, Mass.; Charles H. Andrews, Marlboro, Mass.; Hon. G. Louis Richards, Mayor, Malden, Mass.; H. S. Richards, New London, Conn.; L. H. Cornfel, Boston; C. H. Cooley, Westfield, Mass.; Fred M. Hutchinson, Somerville, Mass.; George A. Carpenter, Pawtucket, R. I.; E. E. Pinkham and D. A. Sutherland, Lynn, Mass. — 21.

[Names counted twice — 5.]

The President called upon Mayor Richards, of Malden, who addressed the Association briefly.*

THE PRESIDENT. I now have the pleasure of presenting to you, gentlemen, the Hon. S. O. Bigney, of Attleboro, who, as our friend the Mayor has said, will now proceed to furnish the oratory. Colonel Bigney represents one of the largest manufacturing jewelry establishments in the country, and has had the privilege and honor of serving as a member of the Governor's Council.

COLONEL BIGNEY. *Mr. President and Gentlemen,* — I am glad to note to-day that you are all on the water wagon. The Mayor has told you just what I am going to say, how I am going to say it, etc.; and he has also told you how good looking you are. Well, I agree with him; as I look into your faces I can see that you are all very good-looking, and that is no bouquet at all. I understand, by the way, that you men seldom give up your business after you once get hold of it, but you stay and stay for all time, or as long as you live.

I know you have a lot of business to attend to this afternoon. But as I listened to the tunes which were played by the orchestra over there, a little while ago, I was reminded that this was the birthday of Abraham Lincoln, the greatest American citizen living or dead, without any question. All any one has to do is to read the life of Abraham Lincoln and he will agree with that statement. No man yet has ever done justice to the memory of that great American, nor can he.

It is hard for us to-day to appreciate this splendid heritage which has been passed down to us. We cannot begin to appre-

* A report of Mr Richards' remarks was sent to him for revision, and has not been returned to the Editor up to the time of going to press.

ciate it unless we go back and read afresh the history of that great man's life, and the history of the Civil War, and think of the suffering of those who made it possible for us to enjoy the splendid inheritance which is ours.

Gentlemen, I am pleased to be here to-day; I am glad to look into your faces. Two of my fellow-townsmen from Attleboro are here. We have been doing great work in our town in bettering and increasing the efficiency of our water works. Of course we have been criticised for spending too much money, but we had to do it in order to meet the demands of our community. I feel satisfied that my friends can take care of themselves anywhere, even at home when our next election comes on. I thank you very much, gentlemen, for your kind attention. [Applause.]

The President called upon Mr. Morris Knowles, chief engineer of the Bureau of Filtration, Pittsburg, Pa., to open the consideration of the subject especially assigned for the afternoon, which was, "Filter Operations, Investigations for Additional Supply, and Construction of New Filter at Lawrence, Mass." He was followed by Mr. Arthur D. Marble, city engineer, Lawrence, Mass., who gave a history of the agitation of the subject in Lawrence, finally culminating in the construction of the new filter; Stephen DeM. Gage, biologist, Massachusetts State Board of Health at the Lawrence Experiment Station, who illustrated by lantern slides the construction of the new filter and made some particular reference to the bacterial results obtained by filtration and the effect on the health of the community; Sanford E. Thompson, consulting engineer, who spoke particularly of the collapse of a portion of the roof of the new filter during process of construction; and M. F. Collins, superintendent of water works, Lawrence, who spoke of the matter of typhoid fever.

The general discussion which followed was participated in by Mr. M. N. Baker, Mr. Robert S. Weston, and Mr. Charles N. Taylor.

The Secretary read applications for membership from the following-named persons, all of which had been properly recommended and approved:

Active. — Charles W. Gilbert, Woburn, Mass., student of state and local management of public water supplies; Frank H. Gun-

ther, Dracut, Mass., superintendent, Dracut Water Works; Richard D. Chase, New Bedford, Mass., with National Board of Fire Underwriters; Robert Ridgway, Poughkeepsie, N. Y., Board of Water Supply, New York City.

Associate. — Allen & Reed, Inc., steam, gas, and water-works supplies, Providence, R. I.

The Secretary was instructed to cast the vote of the Association in favor of the applicants above named, and, he having done so, they were declared duly elected members of the Association.

The Secretary read a letter from Mr. S. E. Tinkham, Secretary of the Boston Society of Civil Engineers, inviting the members to attend a meeting of the Society on Wednesday, February 19, at which Mr. Allen Hazen would describe his trip to Australia " and show a large number of lantern slides of the Brisbane Water Works, the Sidney Water Works, the Melbourne Sewerage and Sewage disposal, and many views of public interest."

Mr. George Bowers called attention to the fact that there is now pending before the Massachusetts Legislature a bill appropriating $10 000 for the making of a geological map of the state. The United States government, if the bill is passed, will also make an appropriation for the work equal to the amount appropriated by the state. He spoke of the great importance that such a map would be to water-works interests, and asked the members to urge their representatives in the legislature to vote for the bill, which is Senate Bill No. 47.

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., January 8, 1908.

Present: President John C. Whitney and members D. N. Tower, Robert J. Thomas, A. E. Martin, L. M. Bancroft, George W. Batchelder, George A. King, Charles W. Sherman, and Willard Kent.

Four applications were received and recommended for membership, viz.:

George W. Cutting, Jr., civil engineer, Waltham, Mass.; Milton W. Davenport, chemist in charge of sewerage filtration plant, New Britain, Conn.; William Atkins McKenzie, civil engineer, Meriden, Conn.; Walter E. Spear, Division Engineer, Board of Water Supply, Babylon, Long Island, N. Y.

The committee on investment of funds reported recommending the purchase of bonds of the Lake Shore & Michigan Southern Railway, and, on motion of Mr. Sherman, seconded by Mr. Martin, and amended by Mr. King, it was voted:

The Treasurer be, and hereby is, authorized to invest funds of the Association to an amount not exceeding two thousand dollars ($2 000) in bonds of the Lake Shore & Michigan Southern Railway.

On motion it was —

Voted: That certain persons suspended from membership in the Association for non-payment of dues, which have now been paid, be and hereby are reinstated.

No further business appearing, meeting dissolved.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., February 12, 1908.

Present: President A. E. Martin and members M. F. Collins, Robert J. Thomas, William F. Sullivan, L. M. Bancroft, D. N. Tower, George A. King, Charles W. Sherman, M. N. Baker, George W. Batchelder, and Willard Kent.

Applications were received and recommended for membership from:

Charles Walter Gilbert, of Woburn, Mass.; Robert Ridgway, of Poughkeepsie, N. Y.; Frank M. Gunther, of Dracut, Mass.; Robert Davenport Chase, of Westfield; and from Allen & Reed, Inc., of Providence, R. I., for associate membership.

Voted: That the June meeting of the Association be held at Plymouth, Mass., and that the President, Secretary, Editor, George A. King, and D. N. Tower, be a committee with full power to make all necessary arrangements.

The subject of the place for holding the next Annual Convention was brought up and, after discussion, the members were unanimously of the opinion that, if suitable arrangements could be made, it should be held at St. John, N. B., and the President, Secretary, Editor, George W. Batchelder, and William F. Sullivan were made a committee to make necessary arrangements therefor.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

OBITUARY.

CHARLES HERMANY, chief engineer and superintendent of the Louisville, Ky., Water Company, died at his home in Louisville, on January 18, 1908.

Mr. Hermany was born in Lehigh County, Pa., on October 9, 1830. In 1853 he entered the office of the city engineer of Cleveland, Ohio, and in 1857 he went to Louisville and became connected with the water company. In 1861 he became its chief engineer and superintendent and held the position continuously until his death.

It was under the direction of Mr. Hermany that the filtration experiments were made by Mr. George W. Fuller which mark the beginning of mechanical filtration as a scientific process.

Mr. Hermany was president of the American Society of Civil Engineers in 1904. He was elected an honorary member of the New England Water Works Association on September 14, 1904.

BOOK REVIEW.

MODERN BATHS AND BATH HOUSES. By Wm. Paul Gerhard, C.E. New York: John Wiley & Sons. 1908. 311 pp., 5¾ x 9¼ inches. Many illustrations. $3.00 net.

To the ordinary reader it would seem that this book must contain almost all that could be written on the subject of baths and bathing. Yet the bibliography composing one chapter of the book covers seven pages and indicates that the subject is by no means exhausted. The book describes not only water baths, but also air baths, mud baths, medicinal baths, etc. The illustrations show all kinds of apparatus, as well as plans and views of baths for various purposes, and sixteen pages are devoted to complete specifications for a municipal bath-house. There is a good index.

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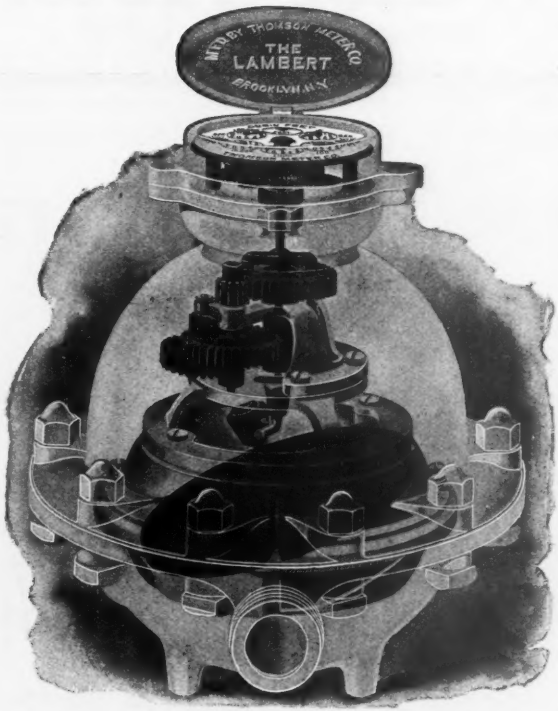

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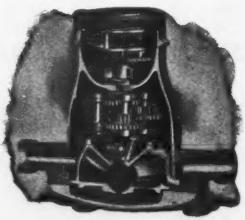

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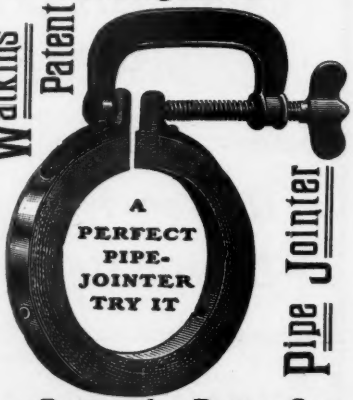

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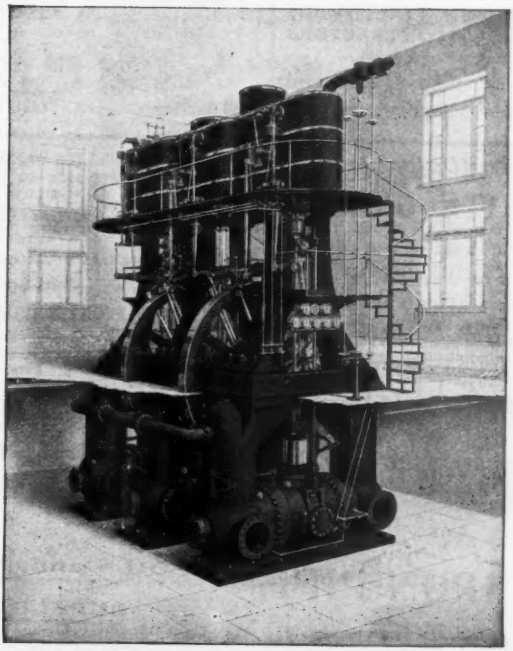

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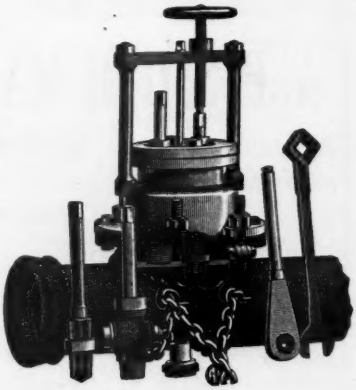
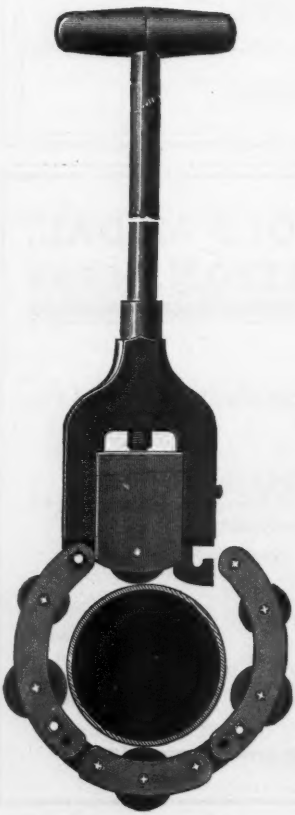


Manufacture and control



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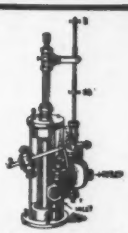

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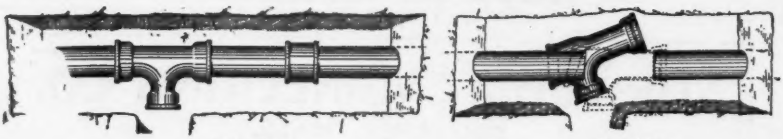

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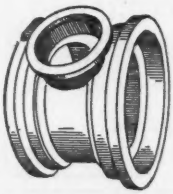

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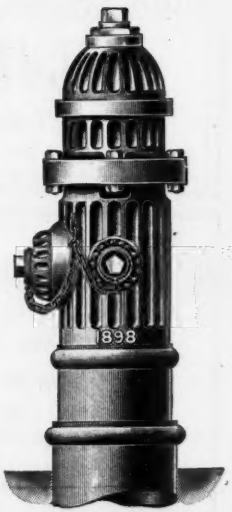

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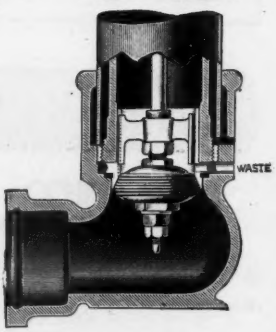

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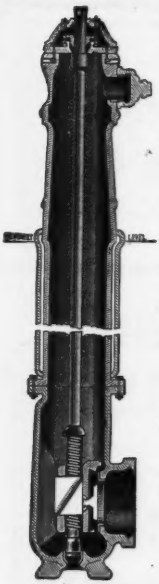

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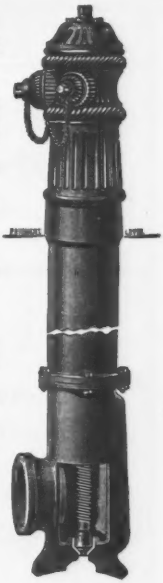

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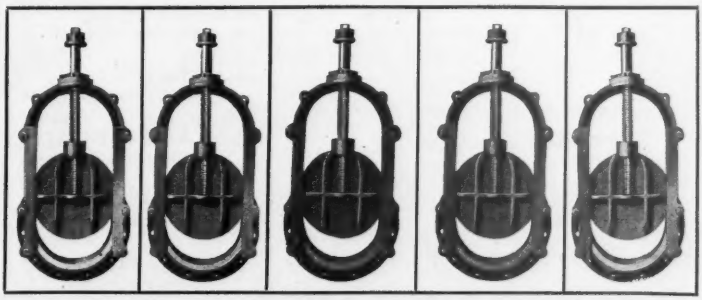

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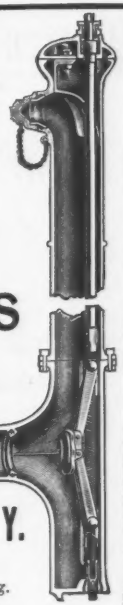

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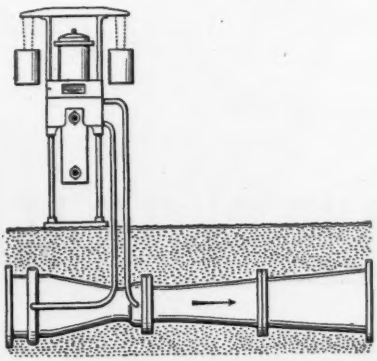
USES OF THE VENTURI METER

SLIP OF PUMPS



IN the pumping station of a large Filtration Plant two Horizontal Duplex Pumping Engines, each of 2,500,000 gallons daily capacity, were recently installed. The water pressure was 100 pounds per square inch and the pump plungers were not of the "packed" type but moved in plain bronze bushings which were, however, of ample length and otherwise of good design. About thirty large Venturi meters are in use on this Water Works System, and one of these is arranged to accurately measure the discharge from either of the above pumps. This meter showed that although the No. 1 pump had a slip of only 3%, yet the No. 2 pump had a slip of about 15%! A critical examination of this latter pump was therefore made and it was found that the clearance between the pump plungers and their bushings was excessive. When this defect was remedied the slip as shown by the Venturi meter was reduced to about 3%.

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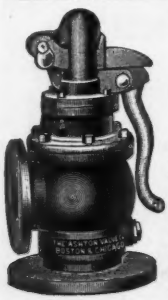

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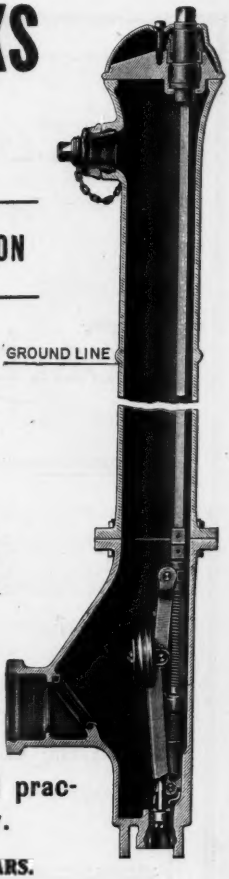

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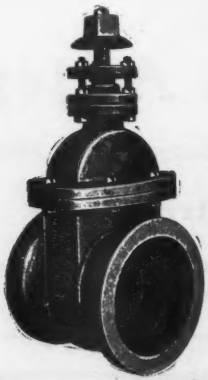

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